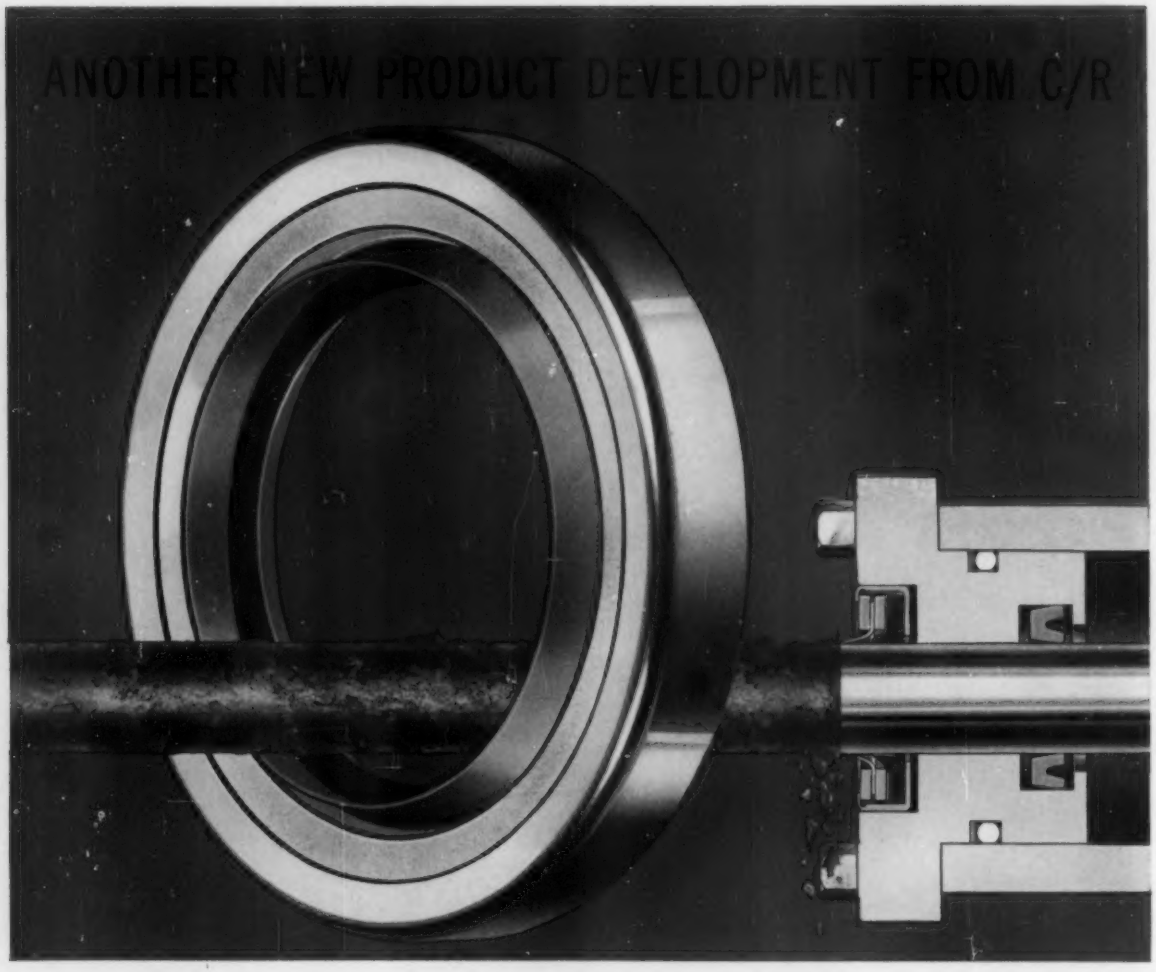
$3 A YEAR

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · MAY 23, 1960

first annual design awards

Judges choose 11 for design awards . . . see page 38



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Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

May 23, 1960 Vol. 31, No. 21

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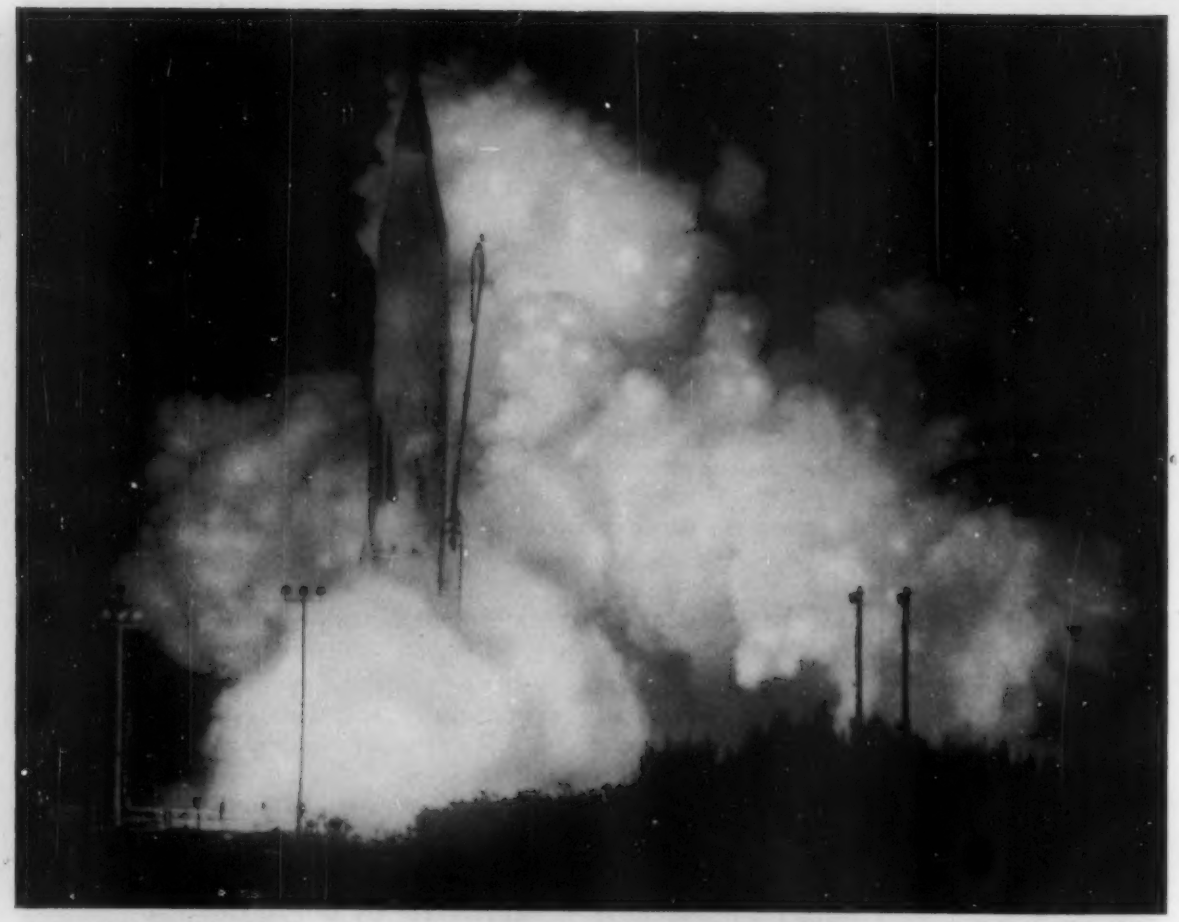

Record breaking Atlas missile billows flame and vapor as she launches 4¼-ton satellite into orbit. Constructed of Type 301 Nickel Stainless Steel, Atlas is built by Convair (Astronautics) Division of General Dynamics Corporation. *U.S. Air Force photo*

130 tons of missile with a skin thinner than a window pane!

The Nickel Stainless Steel skin of the Atlas missile is actually about one-third as thick as the glass in your window.

And yet look what this skin does:

- It is the sole structural framework for Atlas—130 tons of dead weight at the moment of firing.
- It serves as the wall of the propellant tanks in Atlas' weight-saving design.
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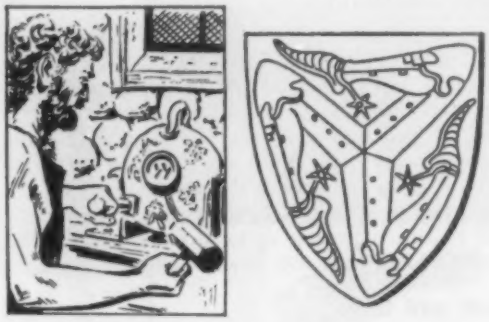
INTERESTING TO NOTE

On our cover—the judges who selected the winners in our first annual Design Awards competition. From left to right: Arthur M. Perrin, president, National Conveyors Co Inc; Renato Contini, senior research scientist, College of Engrg, New York Univ; George Habach, vice-president, administration, Worthington Corp; Milton Immermann, Walter Dorwin Teague Assoc; John H. Robinson Jr, manager, advance engineering, General Electric Co; Robert Redman, professor of industrial design, University of Bridgeport. Mr. Immermann represented Mr. Teague who was ill. Conrad Jones of Booz, Allen & Hamilton, originally scheduled to be one of the judges, had to be out of the city that day. The winners? See page 38 for a description of who they are and why they won.

Originality in design and the desire to proclaim one's individual creativeness dates back to sometime around 6000 BC when an obscure Near Eastern potter scratched a triangle on the side of a clay pot he had completed. This piece, now in the British Museum, is the earliest known trademark. In essence, this potter wanted to identify his wares and distinguish them from those of other potters. Within 3000 years other potters were marking their products and Egyptian wine merchants labeled their jugs with seals made out of Nile mud. Later, pride in workmanship led the weapons maker and carpenter to etch their own distinctive mark on each finished product. Still later, papermakers added their symbol—the watermark on every sheet.

Meanwhile, organizations of craftsmen had gotten into the act. In England, for example, the purity and quality of precious metals was carefully tested in the great hallways of the guilds. Those that passed this careful scrutiny were stamped with the mark of the hall. These labels were more than marks of distinction; they became standards of quality. In 1266 an English law was passed, decreeing that bakers had to mark each loaf of bread so that if a faulty one turned up, "it will be knowne in whom the fault lies."

Soap makers of Rome were fined heavily when caught producing unbranded soaps; their rights to manufacture were also sharply curtailed. Flemish tapestry workers who



failed to mark their products were punished by amputation of right hands; innkeepers who sold unmarked brands were hanged. Although penalties are no longer that brutal, seals and trademarks still carry many obligations and responsibilities.

continued, next page

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Lights On

One spring evening 81 years ago, several thousand people gathered at the public square in Cleveland. Surrounding the square stood a dozen wooden posts. These supported glass boxes similar in shape to the familiar gas lamps, but much larger. Beside one of the posts stood Charles F. Brush, inventor of the arc light. At five minutes to eight. Brush gave a signal. There was a flicker of light and then, to everyone's astonishment, 12 carbon-arc lamps lit up, each glaring with an intensity of 2000 candlepower. A shout went up from the crowd, the Cleveland Grays Band began to play, and an artillery piece on the lake shore fired a triumphant salute.

Brush's demonstration ended one lighting era and ushered in another. The automobile was still several years off and Thomas Edison had yet to perfect his incandescent light, but already streets were being lit by lamps stronger and brighter than gaslight. The lighting industry has taken many forward strides since Brush's demonstration in 1879. The news story on page 15 describes one of the latest developments—lighting an airborne optical beacon which can generate up to 82 million lumens. This is the equivalent of 16,000 50-watt bulbs.

Jack and Gill

The responsibility of establishing and maintaining standards, in the US, is undertaken by the National Bureau of Standards. Its director, A. V. Astin, discusses some of the bureau's problems on page 24. His bureau tries to remain out of the political spotlight; however, standards agencies have not always managed to stay in the background.

During the 17th century, King Charles I of England decided to replenish funds in the royal treasury by using standards to his advantage. In those days the English people purchased their cereal grain in very large containers called "jacks" or "jackpots"; two jacks were called a "gill." There was a moderate sales tax on each jackpot of grain sold, and the king hesitated to raise this tax. He solved his financial dilemma by issuing a decree that reduced the size of the standard jackpot. It didn't take the poor consumers long to realize that they had to buy three or four more jackpots a week to get the same amount of grain.

Since England was an absolute monarchy then, no direct governmental criticism was tolerated.

So, instead of letters, rallies and petitions, the people made known their disapproval by composing nursery rhymes. Their resentment against the shrinking jackpot led them to compose "Jack and Jill."

—Benedict A Leerburger Jr

COMING NEXT WEEK IN PRODUCT ENGINEERING

. . . 15 Ways to Fasten Gears to Shafts
A roundup of methods, some old—some new, plus a comparison table to help make the choice.

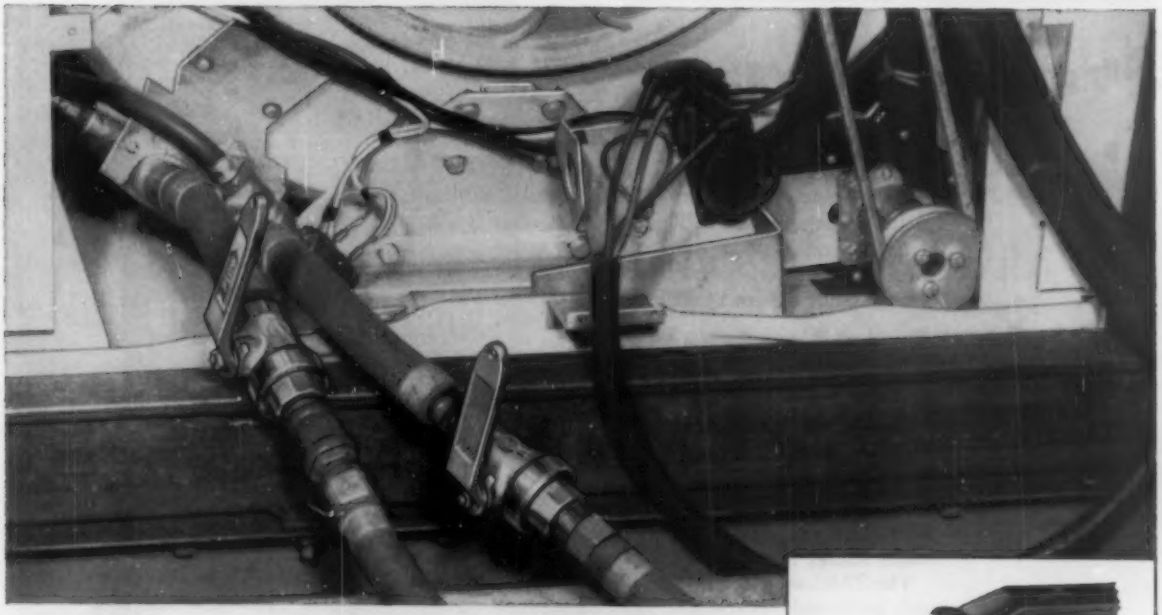
. . . Metal Fiber Composites
They give high-temperature static seals that will handle 5000 psi air at 1000 F.

. . . Choosing the Right Belt Drive
An up-to-date evaluation of the available types of belt drives—with a summary of their operating characteristics.

. . . Preparing Better Technical Catalogs
Those responsible for a poor catalog often forget or ignore the catalog's prime function.

. . . Building Strength into Brackets
They must meet such specific requirements as stability and light weight. Here is a guide.

HUNDREDS OF THOUSANDS OF TURNS AND 2 YEARS LATER . . .



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In the Easy Laundry Appliances Division, The Murray Corporation of America, Rockwood Ball Valves prove their dependability day after day. Used in the 100% testing of the famous EASY Golden Regent automatic washing machines for water load, leakage and rinse cycle selections, these ½" Ball Valves are opened and closed hundreds of times a day. Now after two years in operation, these Rockwood Ball Valves are still leakproof and require no maintenance.

Their full, round flow, tight seal and smooth, easy opening and closing features provide the highly efficient valve performance required by this manufacturer.

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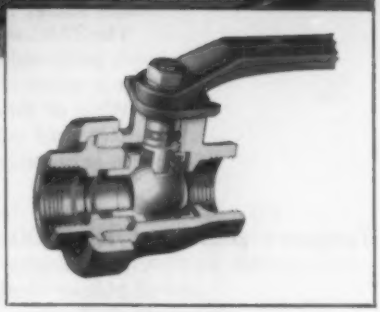

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DEVELOPMENTS TO WATCH...

Better materials coming for new power sources

Materials with higher current density and greater physical compactness—for use in thermionic energy-conversion devices—are being developed at Naval Research Lab. In these converters a current is made to flow by "boiling" electrons from a hot cathode and collecting them on a cold anode (*PE—July 21 '58, p 17*).

By operating thermionic refractory metals and ceramic-type material closer to their melting points, says H. F. Kaiser of NRL, there is a strong possibility that much higher current densities can be achieved. Tests with tungsten have already shown that current density can be appreciably increased by higher temperature operation; and special equipment is being designed for further studies.

Liquid metal cools arc furnace

Better, safer cooling of consumable-electrode arc furnaces can be achieved by substituting a liquid metal alloy for water, D. E. Cooper and E. Don Tilling of Titanium Metals Corp told a recent AIME conference.

The alloy is a sodium-potassium composition which "has a fluidity at room temperature similar to water," eliminates explosion and contamination hazards encountered with water, and requires only minor adaptions for handling with standard equipment. Major change is in the valves, which must be specially designed for liquid-metal use.

The TMC men add that installation cost of the liquid-metal system is "competitive with safety-vault construction required for water-cooled installations," and maintenance cost is minor.

What of the potential hazards of the sodium-potassium alloy itself? These, they believe, need cause no alarm if the system is properly designed. A test installation has been in operation for nearly two years without any serious trouble.

Tungsten protected to 3000 F

Vitreous-bonded refractory systems that can protect tungsten from oxidation at 3000 F and above "for several hours" have been developed at the University of Illinois; and C. G. Bergeron, V. J. Tennery, and A. L. Friedberg report the new systems may well make it possible to take advantage of the high-temperature structural strength of this refractory metal by suppressing the rapid formation and volatilization of tungsten oxide.

New aircooled engine developed in Britain

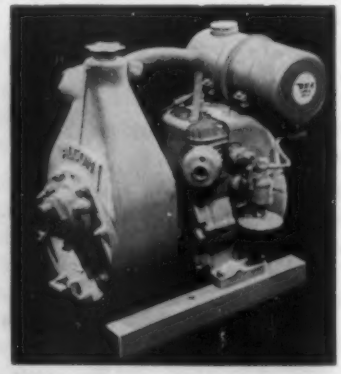
A new line of engines for cultivators, charging sets, pumps, and lawnmowers is being introduced by the Power Unit Div, BSA Motor Cycles Ltd, Birmingham 11, England.

These are aircooled, 4-stroke engines, weighing about 23½ lb, and developing about 2 bhp at 3600 rpm. Capacity is 87 cc.

Crankcase and barrel are cast iron; cylinder head, piston, connecting rod, and crankcase end-cover are aluminum. Several end-cover designs are provided to adapt the engine for vertical-shaft operation and other installation requirements.

Lubrication in the standard model is by splash from the sump. In the vertical-shaft model, oil is carried to the top main bearing by screw feed through the hollow camshaft, and the end-cover acts as a sump.

"Standardization of design and interchangeability of parts between different models," says BSA, "have substantially reduced costs."



BRITISH 4-STROKE ENGINE, here coupled to 1½-in pump, can be adapted for vertical or horizontal operation, is dimensionally interchangeable with American equivalents.

CHOICE OF BUILT-IN VALVES GIVES CONTROL FLEXIBILITY

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RUGGED CONSTRUCTION ASSURES LONG LIFE

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But he also wants the knowledge, if service should ever be needed, that it is quickly available wherever his machine may go.
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Man-made "natural" rubber coming—but slowly

Will man-made "natural" rubber—polyisoprene and polybutadiene (*PE*—Oct 5 '59 p 14) take natural hevea (tree) rubber's place? Not soon, if production figures are any indication.

Right now, there is only one isoprene supplier–Shell Oil Co–turning out about 22,000 tons a year. By midyear, Phillips Chemical hopes to be producing about the same amount of polybutadiene. At year's end, Firestone may have enough equipment on line to turn out its polyisoprene material at an annual 30,000-ton rate.

In 1961, a plant of about the same size should be producing for Goodrich-Gulf. Goodyear and General Tire are expected to join the parade—but certainly not before next year, if then.

That means total capacity for man-made natural rubber a year from now will be on the order of 100,000 tons—not much compared to current consumption of 550,000 long tons of natural rubber and 1,000,000 long tons of synthetic.

What's holding man-made natural back? Not price. Shell's material sells for 30¢ a lb, well below the current price of natural rubber. The big problem—quite aside from the investment in plantations—seems to be the fear of new developments that will make present rubbers—both natural and man-made—obsolete. The rapid development of butyl, polyethylene, and polyurethane rubbers, and the promise of still better synthetics to come, make producers cautious about investing large amounts in new plants. Too, plastics are increasingly taking over such traditional applications of rubber as gaskets, floor tile, and cushioning.

It looks very much as though, for the next five years at least, designers will be using natural (hevea) rubber, general-purpose synthetics, and the newer elastomeric resins. Man-made natural will be available for evaluation and for some commercial applications, and new specialty rubbers will be coming along (see below).

More specialty rubbers coming up

Commercialization of man-made "natural" rubber (see above) may seem slow. But there's no lack of research activity in the field. Having duplicated the general-purpose hevea tree rubber, researchers are now out to synthesize the special-purpose natural rubbers as well.

Gutta percha is one example. This specialty rubber has been in short supply for some time, and its price is high: about $5/lb. Not surprising, then, that there have been attempts to duplicate it in the laboratory even though total consumption is rather small. (It's used primarily for golf ball covers.) Now, Phillips Petroleum Co announces that a modification of its polybutadiene rubber promises to do the job.

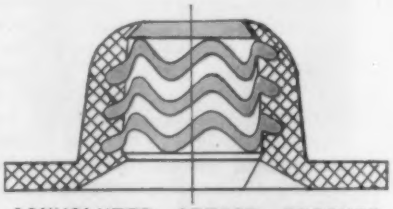
The newcomer (technically known as Trans-4 polybutadiene) is being produced in pilot quantities, and Phillips believes its applications may extend well beyond the golf ball field—to gaskets, drive belting, wire and cable covering, and molded parts.

Germans claim improved thermocouples

For temperature measurement in the 2700-3600 F range, the German Gold and Silver Institute has developed a thermocouple in which one element is an iridium-rhenium alloy, and the other is iridium, tungsten, molybdenum, or another iridium-rhenium wire. A British patent, No. 822,916, gives the details.

Germans develop new shaft seal

This seal for rotating members has its own built-in grease chambers. Developed by SIS-Thelen, Hangelar, Siegkreis, Flughafen, Germany, it is now available for overseas sale. Molded of rubberlike plastic, it has three convoluted grease grooves and sleeve-type sealing lips at top and bottom. The company is making it to fit shafts of 22 to 35 mm dia, and has a leaflet in English describing it. —ARG



CONVOLUTED GREASE GROOVES hold lubricant, and rubber lips at top and bottom seal it in.

WHAT'S HAPPENING IN RESEARCH . . .

NASA computes minimum strain for pressure vessels

In cylindrical and spherical vessels subjected to internal pressure and heating, there is a minimum possible strain that occurs at a particular wall thickness, says NASA's Lewis Research Center.

Its scientists have studied elastic-plastic stress distribution in internally cooled containers of this type, and subjected them to almost the worst possible conditions: pressure, heat, and nuclear radiation.

The work was done with reactor tanks made of Inconel X; but LRC's researchers believe results apply to most metals that might be used.

Other findings:

- Average tangential stress for optimum wall thickness is essentially constant for a given material, varying only about ±5% throughout the range of heat flux and pressure load investigated; but the strain varies considerably.
- The equivalent total strain increases at a lower rate than the heat flux over the range of heat flux investigated.
- In units having a length-diameter ratio equal to unity, a spherical containment vessel is subjected to 70 to 80% of the strain a cylindrical vessel receives; while a hemispherical end on a cylindrical vessel would be subjected to 30% less strain than the cylinder itself.

Donald F. Johnson of LRC has prepared a report giving equations used for analysis and charting results.

Ceramic and cermet "bank" to provide new data

A collection of ceramic and cermet samples is being set up at National Bureau of Standards. Purpose: to obtain and publish essential data necessary for effective use of these materials—especially in new high-temperature applications. The first report has just been released as NBS Monograph No 6. It gives elasticity and density constants at room temperature for 20 different oxides, carbides, borides, and cermets, based on a "bank" of more than 40 specimens collected from commercial and laboratory sources.

This monograph may be obtained from the Government Printing Office, Washington 25, DC for 20¢. It's 46 pages, more than half of them charts, detail shear, bulk, and Young's moduli, and other factors. Further work is now in progress.

Research aims for higher temperature resins

Phosphorus, sulfur and boron fluorocarbons are being prepared at U of Southern California's chemistry lab as one approach to the development of resins serviceable at 1000 F and above.

Prof Anton Burg of USC points out in a report to Wright Air Development Center that few if any of the compounds so far prepared seem immediately useful as plastics; but they do pave the way for a variety of new-type compounds that offer promise as thermally stable polymers.

Also under study at USC: phosphorus-boron and phosphorus-aluminum compounds, which may also prove to be useful steppingstones.

briefs . . .

An infrared test console that combines in one unit the components necessary to measure photoelectromagnetic and pyrodetector characteristics is being made available by Infrared Industries Inc, PO Box 42, Waltham 54, Mass. Unit is said to measure black-body sensitivity (in the temperature range 350 F to 1000 K) and spectral response (from 1.0 to 5.5 microns in 0.5-micron steps) as functions of frequency, noise-band width and bias voltage.

Rare-earth elements and their properties are outlined in a new 8-page brochure available from Vitro Chemical Co, 342 Madison Ave, New York 17. It contains latest data on this up-and-coming group of metals (*PE* —Apr 25, p 39), plus thorium.

—ARG

Modeling the big testers

Test setups for the jet age are getting so big and costly, their owners are building models of them, just as they do for big production plants. Pictured here are two recent examples: one for conveyor-belting endurance tests at Goodyear's Industrial Products Div; the other for human-engineering space studies at Lockheed's Marietta, Ga lab.

WILL CONVEYOR BELTING stand speeds to 2000 fpm, stresses to 250,000 psi? This machine should provide the answers. It will permit operating tests on belting up to 60 in. wide, 60 ft long, will be powered by twin 1000-hp motors. Expected cost: $250,000.

CAN A WEIGHTLESS MAN eat and sleep normally? Lockheed is installing this machine to find out. To simulate weightlessness, it will submerge subject in tank of water, revolve him rapidly until he loses normal references for equilibrium.

(ADVERTISEMENT)

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

No difference between hex and cap screws

It's not the *name* of a standard fastener that determines whether to use it for a particular application, but vice versa. The *application* requirements for strength and tolerances dictate the fastener.

Thus, if you have a joint that calls for certain tolerances in a screw, obviously the one which satisfies those tolerances is the right fastener.

IDENTICAL STANDARDS

In the case of cap screws and hex screws, the standards will show you that these are merely different names for the same product. They're actually made on the same machines, to identical tolerances, and from identical materials.

No reason then to differentiate. For tapped holes, merely specify Hex Screws (SAE Grade 2) or High Strength Hex Screws (SAE Grade 5), and you'll get the *right* fastener with the quality needed.

For bolted joints, these same items are supplied with nuts when specified.

This should suggest a way you can extend standardization in your plant . . . and benefit from our new simplification of nomenclature which calls *any* fastener with head on one end and threads on the other a *screw;* and a screw plus nut a *bolt.*

See how "holding power" can cut fastener costs

SIZE	SAE GRADE	SAE PROOF LOAD	COST RATIO
¾"	Gr. 5	28,400 lbs.	100%
1"	Gr. 2	16,950 lbs.	188%
1⅛"	Gr. 2	21,350 lbs.	239%
1¼"	Gr. 2	27,100 lbs.	277%

Since the usual job of a threaded fastener is to hold an assembly tightly together, its *clamping force* is what you're really utilizing. This seems obvious. But how best to get the clamping force needed for the joint design? Not so obvious. Looking at size alone can be misleading . . . *and quite costly,* as the chart above demonstrates.

HOLDING POWER MEANS MORE THAN SIZE

SAE "proof load" of four different hex screws of standard steels, along with typical cost ratios, are compared. Almost unbelievable, isn't it? Yet it's a fact that the smallest of the group—the heat treated SAE Grade 5 *RB&W High Strength Hex Screw* exceeds all the others in load capacity. It can be used in place of any of the others in most normal usages.

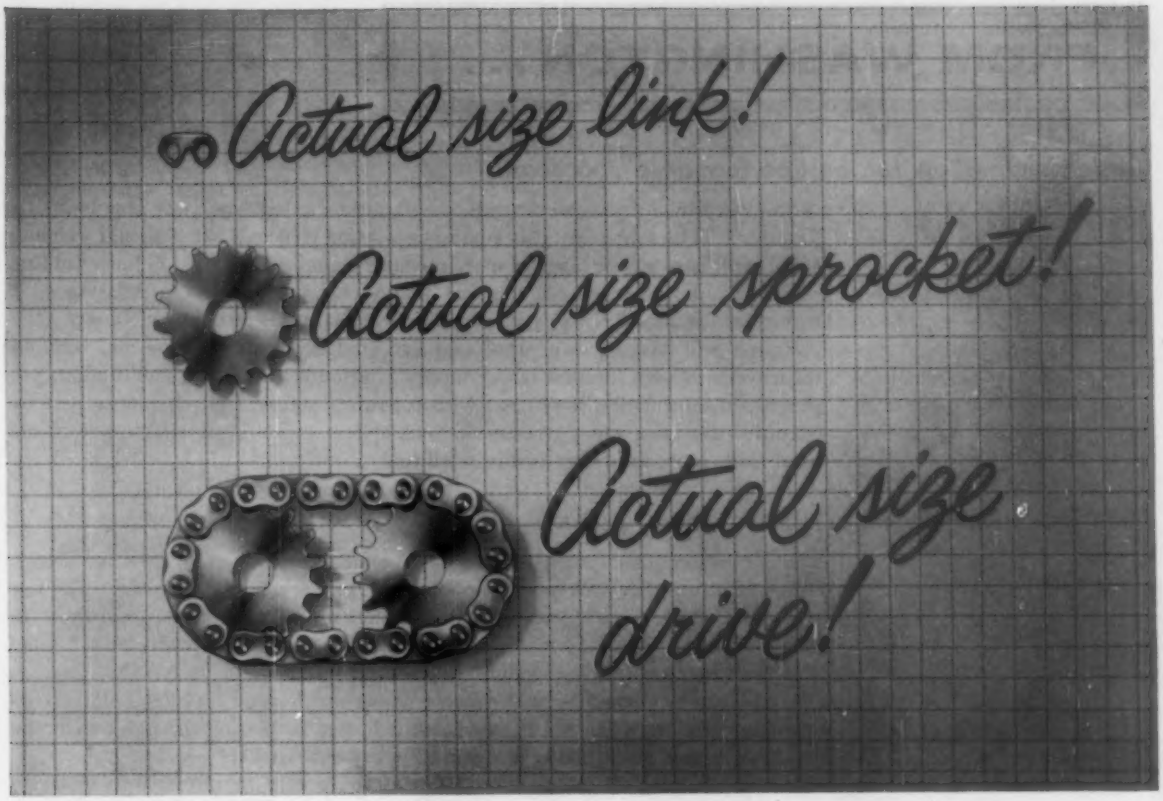
Since it's smallest and therefore weighs the least, it also costs less... 64% less than the 1¼-inch grade 2 hex screw; 58% less than the 1⅛-inch; 46% less than the 1-inch. And since holes can be made smaller, there are also the savings in production drilling . . . and possibly in materials, too.

DESIGN ADVANTAGE

Remember, too, that smaller fasteners are more easily torqued to higher preload levels . . . which helps keep joints tight, makes them more vibration-proof.

If you would like to explore this approach to fastener economy and better utilization of "holding power," consult with an RB&W specialist. Let him contribute his fastener knowledge to your design and production needs. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.



. . . and actually over 98% efficient

LINK-BELT 3/16" PITCH SILENT CHAIN

Complete drives as small as two inches! Weight as little as .07 pounds per foot! Efficiency better than 98%! Link-Belt 3/16-in. pitch silent chain is the perfect combination of compactness and split-second precision.

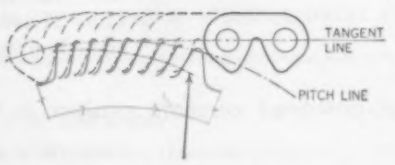
At high or low speeds, this chain is quiet, positive, smooth. In fact, with its unique link design, it's the smoothest-running chain in use today. In many limited-space applications, it has replaced expensive, precision-cut gear trains. And its versatility makes it ideal for a wide assortment of equipment—ranging in diversity from cigar-making machines to guided missile controls.

Available in carbon and stainless steels . . . for ratios up to 12:1, speeds over 7500 rpm. For full details, contact your nearest Link-Belt office. Ask for Book 2510.

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

NO CHORDAL DISTURBANCE!



Exclusive link form of Link-Belt 3/16-in. pitch silent chain permits chain to enter the sprocket wheel on a line tangent to its pitch circle, thus eliminating the undesirable effects of chordal disturbance.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,160

FROM WASHINGTON . . .

Design shapes up for best-performance spacecraft

NASA is rushing design work on the most sophisticated spacecraft ever built, the "Ranger." **This long-lived, continuously operating vehicle, 12 ft high and weighing 800 lb, will have a wide range of space missions including the first US lunar landing.**

First flights are scheduled for next year with launching by an Atlas-Agena B rocket combination. NASA's jet propulsion laboratory is assembling Ranger.

Ranger will have its own propulsion and guidance for midcourse and terminal maneuvers; its own internal power supply; continuous three-axis stabilization; pre-programed information stored as a basis for future action; logic circuits to perform its varied missions; and a communications system exploiting available power and bandwidth more fully than earlier satellites.

'Milk-bottle' engine may provide space power

The nation's civilian space agency is meanwhile evaluating an Avco Corp design for a miniature 30-kw "arc jet engine" that will propel satellites in space. The size of a milk bottle, Avco's proposed powerplant would make corrective changes in altitude or in rotation for a satellite already in orbit. It is simpler and farther along than ion-rocket and plasma engines, also under consideration by NASA.

Avco claims the engine could provide power for "several months." It gets its thrust from helium or hydrogen gas which is heated by passing through an electric arc. The heated gas expands supersonically through a rocket nozzle.

Avco says engine's thrust level is 0.50 to 1.0 lb; specific impulse, 750 to 1500 sec; power level, 25 to 35 kw; and over-all electric to kinetic efficiency, 35 to 75%.

ICBM design changes slated by Air Force

The Air Force is cranking in rapid design changes to scale up performance of Atlas and Titan ICBMs. **New version of Atlas will have range up to 8000 statute miles, compared to 7000 miles of initial model.** (A new engine jacks up total rocket thrust to 380,000 lb, up 20,000 lb of thrust from the earlier MA-2 engine.) It will be all-inertially-guided, and capable of salvo launching. First Atlas missiles are radio guided, can be fired only one by one from sites.

Titan's range is being boosted from 8000 statute miles to some 9800 with bigger second engine. New model will have storable liquid fuels instead of cryogenic types, will have almost instantaneous reaction time. All-inertial guidance will also allow for salvo launchings. For Titan this will mean firing from underground sites. **A new heavy heat-sink type of reentry nosecone to replace ablative type will allow both missiles to carry heavier nuclear payloads.**

The A-powered aircraft project is still being panned

Congress is still sniping at the Pentagon-AEC program to develop an aircraft nuclear propulsion (ANP) system. **In voting out a $150-million budget for the program next year, the House Appropriations Committee calls for a complete review of development work, complains that too much is being spent, with a "relative paucity of results."**

The project was reoriented last year from emphasis on early flight of a primitive plane to design and production of a militarily useful engine.

Says the committee: "This program is a classic example of the obstacles found in attempts to 'invent on schedule' or to attempt to push development at a faster rate than the state of the art will permit."

The Appropriation Committee's comment clashes with the view of the Joint Committee on Atomic Energy which has been pushing to accelerate the project.

How INDEX TABLE *DESIGN* affects INITIAL PRICE and TOTAL COST

Study these drawings to see how the design of an index table affects total costs of an installation. Some tables may be priced lower than others initially, but the additional charges for auxiliary items to adapt them to production requirements, added to maintenance and downtime costs, can make a drastic difference in the **total price.**

The Ferguson Intermittor, indexed by a roller gear drive which operates a minimum of 8,000 hours at speeds up to 2,000 indexes a minute without maintenance, needs no auxiliary locking. It is designed for high speed operation and incorporates rigid integral supports for tooling to eliminate expensive segmental components. The Intermittor dial is supported by tapered roller thrust bearings to withstand heavy loads with little friction. A stationary center tooling support is held rigidly at its top by anti-friction radial bearings and at the bottom by a flanged base bolted to the housing. Hollow center of the support may be used for passage of coolants, fluids, air or vertical shafts to transmit motion to the work surface.

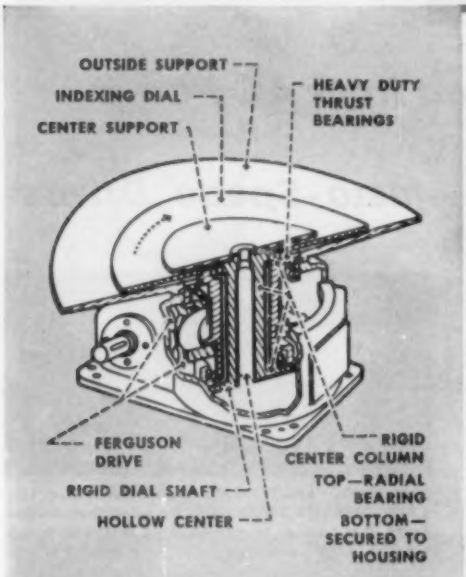


FIG. 1—FERGUSON INTERMITTOR

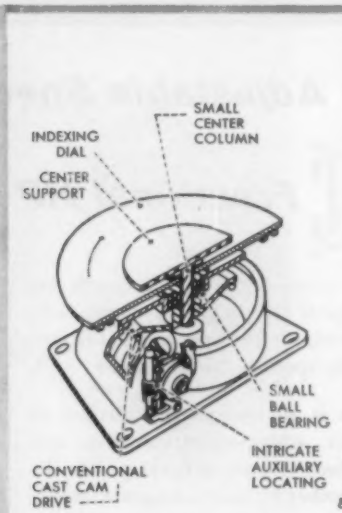


FIG. 2—BARREL CAM TYPE

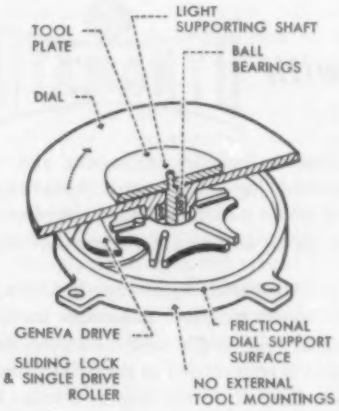


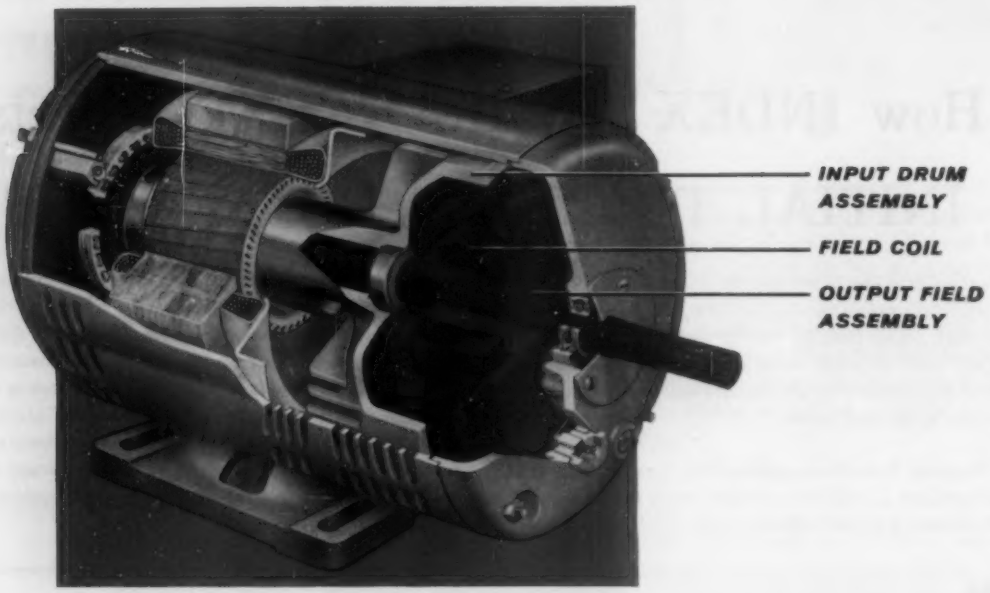
FIG. 3—GENEVA DRIVE TYPE

Figures 2 and 3 show typical barrel cam and geneva drive index tables. Their indexing mechanisms limit operating speeds, therefore other components may be "designed down." Shafts and bearings are lighter; frictional support surfaces might be employed instead of thrust bearings and an auxiliary locking or locating device is a costly necessity for even modest accuracy requirements. Tool mounting methods are often provided at additional expense and sometimes even ignored. Difficulties of installation and frequent maintenance downtime can increase total cost drastically.

• SEND FOR CATALOG

Many other advantages result from the selection of a Ferguson Intermittor. Compare designs in new Catalog No. 160 which contains data on more than 175 standard tables. Every design engineer should have a copy. Get yours by writing:

FERGUSON
MACHINE CORPORATION
A subsidiary of Universal Match Corporation
7818 Maplewood Industrial Court
St. Louis 17, Missouri



Get Stepless Adjustable Speed from AC Power

with DYNAMATIC Fractional HP Ajusto-Spede® Drives

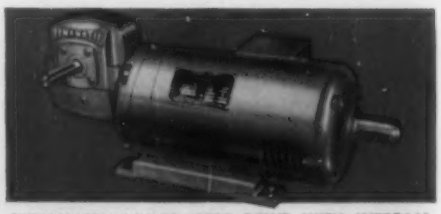
Wherever infinite adjustment and accurate control of speeds are required, Eaton-Dynamatic Ajusto-Spede Drives offer a simple, low-cost solution to the problem—stepless adjustment from zero to full output speed, and accurate control of any speed within the speed range.

The Dynamatic Ajusto-Spede Drive is an integral combination of AC constant speed induction motor, eddy-current coupling, and plug-in type single-tube electronic control. Torque developed in the motor is transmitted to the driven member by electro-magnetic attraction; there is no mechanical contact between the driving and driven members.

Dynamatic Ajusto-Spede Drives operate on standard 115/230 volt, single phase, 60 cycle or 220/440 volt, 3 phase, 60 cycle alternating current—no special power source is required. Sizes are ¼, ½, and ¾ horsepower at 1600 RPM; ½, ¾, and 1 horsepower at 3200 RPM.

With standard, special, or remotely mounted transistorized control, Dynamatic Ajusto-Spede Drives offer many worthwhile advantages not found in other methods of speed control. Send for illustrated descriptive literature.

DYNAMATIC AJUSTO-SPEDE DRIVE WITH ELECTRICALLY OPERATED BRAKE. With the safety type friction brake, it is possible to achieve rapid deceleration and quick stop, thus providing fast cycling operation.



DYNAMATIC AJUSTO-SPEDE DRIVE WITH INTEGRAL SPEED REDUCER. Because of the variety of gear ratios available in the reducer, this compact assembly is adaptable to a wide range of slow speed applications.

EATON — DYNAMATIC DIVISION
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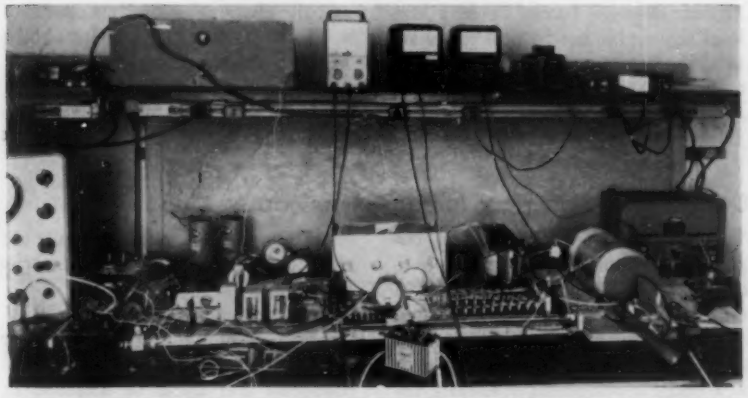
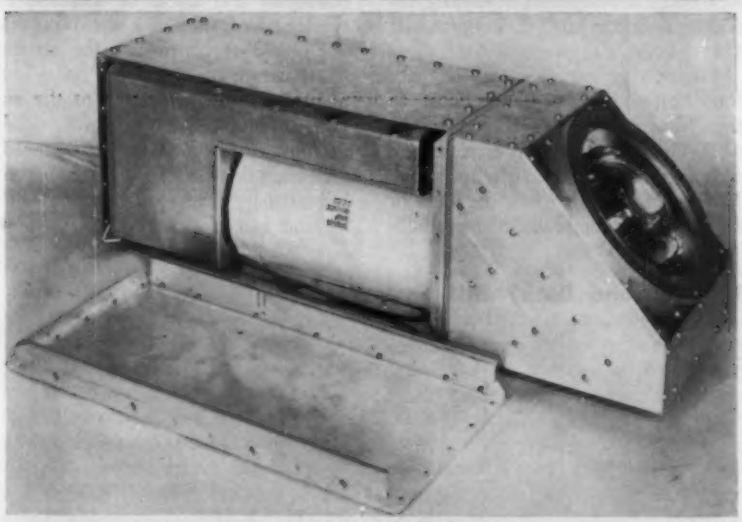
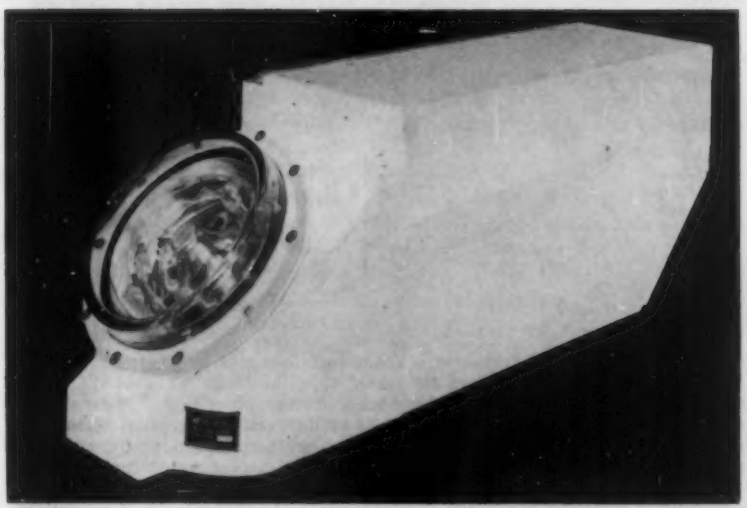
ORIGINATORS OF EDDY-CURRENT SPEED CONTROL EQUIPMENT

THE ENGINEERING WEEK







STEPS IN DESIGN of optical tracking beacon by Battelle Memorial Institute are, from top to bottom: breadboard model, prototype, final production model.

Signal Beacon to Ride Missiles at Night

COLUMBUS, OHIO—To overcome the limitations of radar at low altitude, Battelle Memorial Institute has gone back to a beacon—a high-powered one that flashes 50 million lumens and rides a missile.

It's a controlled flashing light expected to solve the problem of tracking missiles launched at night. At low altitudes, radar is not precise enough. And yet the most critical time of missile flight is often the first 30 seconds.

Developed for Grimes Mfg Co, Urbana, Ohio, the beacon will send its high-intensity signals back to optical trackers—its name is airborne optical beacon. Its flash, equivalent to that of ten thousand 50-watt bulbs, will occur twice a second for 25 seconds. These flashes can be optically tracked or displayed as a series of dots on a photographic plate. From this, missile trajectory can be determined. Flash duration does not exceed 0.001 sec. Actually the high-intensity light is obtained by instantaneously discharging a 4000-v charge from a 21-mfd capacitor into flashtube.

Beacon components include: initiating circuit, relaxation oscillator, multivibrator and amplifier, convertor, high-voltage circuit, and flashtube assembly. Compact unit weighs 33 lb, is 27 in. long by 8 in. square.

DESIGN PARAMETERS

Required accuracy of the flash rate is ±0.001 sec. Radiated light emitted by the flashtube is produced by a minimum electrical input of 150 watt-seconds per charge to the flashtube. Unit is powered by a dc battery of 28-v capacity. This 3-amp-hr battery has a terminal voltage ranging from 45 to 22 v—from no load to full load.

The beacon is capable of withstanding environmental conditions from −80 to 96 F at 100% relative humidity. Also, unit can withstand thermal radiation from missile compartment walls—which reaches 700 F at 90,000-

ft altitude—for three minutes.

Beacon must withstand accelerated peak shocks up to 100 g and complex vibration, including sinusoidal, up to 1.5-g peak to peak from 15 to 25 cps, and 4-g peak to peak from 25 to 2000 cps. Random noise of 0.03 g^2 per cps from 5 to 25 cps and 0.1 g^2 per cps from 25 to 2000 cps is another design factor.

In addition to these requirements, special test circuits are provided for the measurement of the various operating parameters. Circuits include a photoelectric detecting device, a flash-rate detector (for telemetering purposes) and a flashlight-ignition pulse-test circuit.

The flashtube used on the optical beacon is specially designed and similar to a photographic flashtube consisting of a quartz arc tube with an electrode sealed into each end. Quartz is used because high levels of energy are dissipated at each flash.

FLASHTUBE ASSEMBLY

The arc chamber is a flashcoil about 3¼ in. dia, filled with xenon gas, and has a trigger electrode on the external wall. Flashtube is triggered by applying a high-voltage pulse to the trigger, which ionizes the gas. The main storage capacitor then discharges its energy into the flashtube.

The energy levels at which the flashtube operates are about 7500 lumens with a peak of 82 meglumens. The light-flash duration is about 100 microsec.

The extremely high light utilization of the reflector system (about 67%) is made possible by annular-shape lamp and elliptical reflector—instead of the presently-used helical-shape lamps. Advantage: more light can be directed into the beam because there is minimum shielding from the lamp itself. Also the size of the tube is relatively small, resulting in better control over reflected light rays.

BEACON OPERATION

Here's how the beacon operates. The capacitor is charged through a 5000-ohm resistor from a dc-to-ac converter. This converter changes the nominal 28-v battery voltage to 4000 v through a static inverter and high voltage rectifier. The inverter is driven by an amplifier which is controlled by a relaxation oscillator and multivibrator circuit.

The multivibrator operating at 400-cps—the operating frequency of the inverter stage—is turned on by a low-level signal. No mechanical relays are needed. Entire system is static in operation. Semiconductors serve as switches to keep radio interference low and insure high system reliability.

When capacitor is charged to desired 4000 v, voltage-feedback system turns off the multivibrator, stopping the operation of the converter circuit and the charging of the capacitor.

The flashtube timing circuit obtains its pulses from a tuning-fork oscillator. Output of the oscillator circuit and the associated countdown stages produces a two-pulse-per-sec flash. ■

Detachable Jets May Increase Helicopter Capability

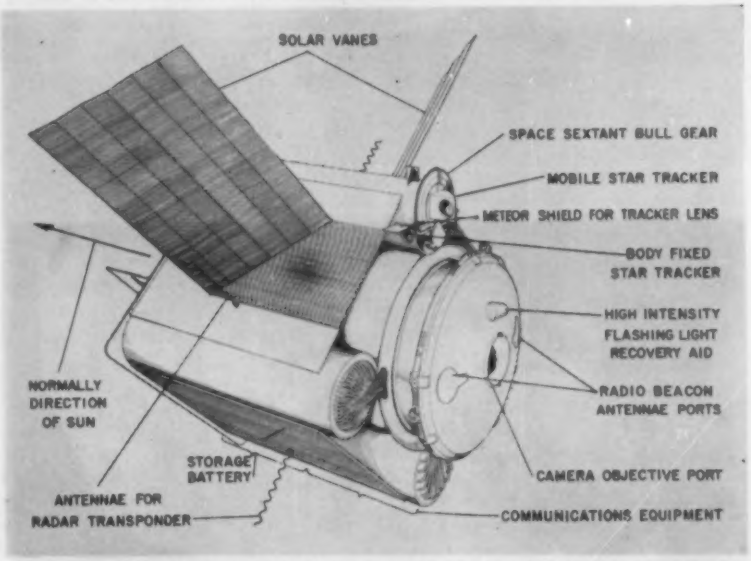
WASHINGTON—A detachable jet engine, pod-mounted on the side of helicopters may become an economical means of giving these craft increased speed, lift, range and versatility. Such a union of jet engine and helicopter is now under development at Kaman Aircraft. The company is using a GE J58 turbojet.

Engineering studies by Kaman show that addition of the jet boosts to the Navy's newest turbine-powered utility helicopter would increase the craft's speed 40%, lift 20% and range 17%. Because the pods are detachable, Kaman sources say, a single helicopter could fly a variety of missions ranging from cargo to air-sea rescue operations.

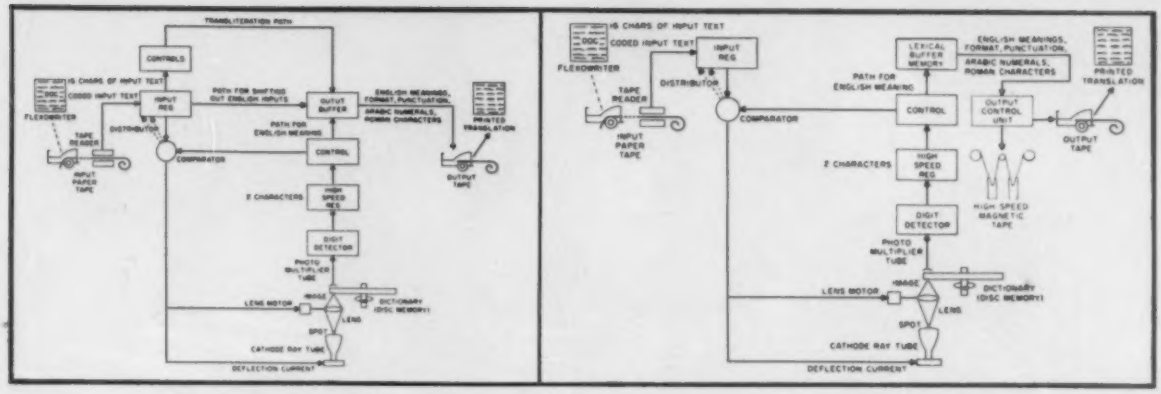
The pod, about 50 in. long, 30 in. dia and weighing 400 lb would be equipped with a simple "plug-in" type connector and could be attached or removed by 2 men in a few minutes.

Directional control of the jet exhaust stream could be pilot controlled or preset through rotation of the engine exhaust nozzle to give either maximum horizontal thrust for speed, maximum vertical thrust for lift or intermediate thrust for boosting both lift and speed. ■

To Mars and Back? MIT Says Yes



Here's an external conception of a spacecraft designed by Massachusetts Institute of Technology engineers for travel to within 5000 miles of the planet Mars. MIT hopes the craft will return with a photograph of half of Mars' surface (a single photo will contain a billion bits of information for earth scientists). The 340-lb vehicle will be launched by rocket booster and guided by automatic navigation; then, after a 2- to 3-year journey, will be recovered from the Gulf of Mexico within 10 minutes of programed timetable. Only obstacle to a 1962 launching is attaining perfection in coordinating the programing of computers, orbital calculations and vehicle operation. MIT engineers are being assisted by Avco Mfg Corp and Thiokol Chemical Corp.



US Gets Foreign Technical Language Translator Capable of Converting at 30-word-per-sec Rate

NEW YORK—An electronic translator capable of translating Russian (or any foreign tongue) into English at a rate of 30 words a second has been developed by IBM for the Air Force. With modifications the machine is expected to translate about 2400 Russian words/min. by the end of 1960. At present the system is translating Russian at 40 words/min—the speed of the Flexowriter.

Heart of the device is a transparent disk 10 in. in dia which serves as the dictionary and stores some 55,000 paired Russian and English words. The words are recorded in clear and black areas 0.000,33 in. square and arranged in 700 tracks ringing the disk. Lens and cathode-ray-tube light source scan the black and clear markings on the disk and "read" the English translation of a Russian word.

Operation of the translation system starts with the input text typed on the input Flexowriter (see block diagram, above). The input Russian characters are coded in the form of holes in an input tape. They are fed into the machine on the punched tape, converted into electric signals, matched with the translation on the disc, then the English version is printed out by an electric typewriter.

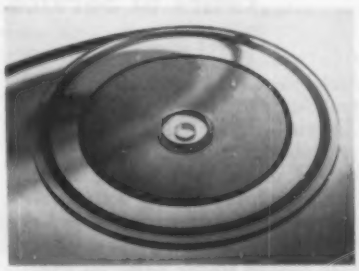
Information from the tape reader is binary coded—six bits per character—and stored in the input register. These characters are then compared with the information being read out of the "dictionary" in order to determine the proper direction to move the lens and cathode-ray tube beam used to scan the disk. This is analogous to a human looking into a printed dictionary at whatever page is open and then flipping pages in the proper direction as a result of reading the first entry. Instead of pages in a printed dictionary, the disk dictionary has tracks.

The light beam continues to step across tracks, reading a small portion of each until the comparator indicates that it has gone too far. The light beam is then stopped and the disk rotation (1400 rpm) allows the reading of every entry on a particular track in about 1/25 sec.

When a proper match to a Russian semantic unit has been found, the corresponding English meaning is read out through the high-speed register to the output Flexowriter. At the same time, logic circuitry has kept an account of the number of input characters or words for which a match has been found. This allows the input characters which have just been translated to be discarded and fresh input characters to be shifted into the input register.

The output buffer is a gathering place for all output characters prior to printing out. It holds one character at a time, receiving it from various sources depending upon the nature of the contents. When no translation whatsoever is required, such as for Roman characters, punctuation, and numerals, the characters come directly from the input register. In the case of Russian word inputs, English meanings come to the output buffer from the disk memory equipment. In the case of input Russian which must be transliterated into Roman characters, such as proper names, the direct transfer from the input register is blocked so that control circuits can allow the transliteration equipment to make the proper changes. When an input Russian word should be translated but cannot be found in the automatic dictionary, it is transliterated. In all cases of transliteration, the output typewriter ribbon color is shifted to red. This feature allows the user to notice at a glance what additions are required in the next edition of the dictionary. Speed of this translating system is sufficient to translate Russian technical literature at an average rate approximately equal to the rate at which it is produced (30 words per sec at present). Only the relatively slow speed of the input and output Flexowriters limits the speed of the system to a substantially lower rate. In the future it is expected that the input speed limitation will be removed by the use of automatic page scanners

continued on page 20



THIS 10-IN. GLASS DISK acts as dictionary for IBM electronic translator. Disk contains 30 million bits of information on 700 tracks in an annulus 0.36 in. wide. Width of annulus is kept as small as possible for rapid access.

Trailer axles take shape as automatic butt welder upset flash welds spindles to each end of 40-inch lengths of Pittsburgh Steel Co.'s mechanical tubing at Kenton, Ohio, plant of Rockwell-Standard's Transmission and Axle Division.

An Axle Axiom: Long Service Life

Pittsburgh Steel Company's Seamless Tubes Give Years of Service in Rockwell-Standard Corp.'s Trailer Axles

Mechanical tubing from Pittsburgh Steel Company covers a lot of ground —in truck trailer axles.

Pittsburgh Steel is a prime supplier of mechanical tubing to the Kenton, Ohio, trailer axle plant where the Transmission and Axle Division of Rockwell-Standard Corp. makes trailer axles for every major trailer manufacturer.

• **Uses C1040 Grade Tubing**— Rockwell-Standard uses AISI C 1040 grade hot rolled tubing, ranging from 4-inch outside diameter with a ⅜-inch wall thickness to tubing 6 inches in diameter with ½-inch wall.

Typical tubing shipped to Rockwell-Standard is made of fine grained steel in a uniform hardness range which enables the customer to develop the final physical properties he wants by heat treatment.

Pittsburgh Steel tubing performs satisfactorily in Rockwell-Standard's processing operations and satisfies the ultimate user—the trailer manufacturer —because we meet these requirements from tube to tube and from shipment to shipment.

Hardness is a prime requirement because lack of uniformity would require more costly operations at Rockwell. With Pittsburgh Steel tubes, heat treating can be standardized with predictable results.

Weldability scores high. Long service life of trailer axles demonstrates the weldability of Pittsburgh Steel's tubing. With an average of

CIRCLE 18 ON READER SERVICE CARD

10 welds in every axle, welds have to be good. Strength and porosity tests prove they *are* good.

Freedom from scale helps promote predictable results from heat treating. Scale would produce steel with different rates of hardness after heat treating. No de-scaling operation is necessary with Pittsburgh Steel tubes.

Uniformity of wall thickness helps to prevent warping of axles in oil quenching and eliminates re-straightening in many cases or holds such operations to a minimum.

• **Tubing first is cut to length** by Rockwell to make axles which will track either 70 inches or 71½ inches, both standard widths. Forged spindles then are flash upset welded, one on each end of the tube. Welds are made simultaneously.

Next, tube and spindle assemblies pass through a high heat furnace on a moving conveyor. For the two hours each assembly is in the 60-foot long furnace it is subjected to a temperature of 1500 degrees F. Each 1½ minutes, an assembly emerges from the furnace to be oil quenched.

To temper the assemblies to the desired Brinell hardness, each passes through a draw furnace where it soaks for an hour in 1000 degrees F.

Rockwell-Standard wants a rating of 269 to 321 for spindles and 218 to 269 for tubing.

Axles then are cleaned by shot in a Wheelabrator and moved to the Machine Shop. Spindles are machined to final contours, welding flash is removed and threads are machine rolled.

• **After accessories,** like spider brackets, diaphragm brackets and cams are welded to the axle, stress relief follows to ease strains set up by welding. An hour's treatment at 900 degrees F. does the trick.

On the final assembly line, each axle gets a brake system fitted to the brake spiders. Nylon support brackets and grease fittings are added, the axle is greased, painted and moved to the shipping platform.

Close-up of brake spider being submerged arc welded. Four welds are made simultaneously.

Pittsburgh tubing, five inches in diameter, is being ground to .4880 inches to meet specifications.

You don't have to be a manufacturer of axles to enjoy the same benefits that Rockwell-Standard gets from Pittsburgh Steel tubing.

Any tube user who wants to lower production costs while making a better product can profit by using Pittsburgh Steel tubular specialties.

You get the physicals you want and you can expect better performance in fabrication. Talk to a Pittsburgh Steel man today. You'll find him in one of the district offices listed below.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
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Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Standard Tube Sales Corp.
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Steel Sales Corporation
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continued from page 17

and character sensing. The output speed limitation can be eliminated by means of high-speed printers and by multiplexing several output units.

System has been in operation since last June, and climaxes an intense effort by scientists, engineers and linguists to design an efficient means of semi-automated translation of Russian technical literature. ■

Systems, Not Hardware, Needed for Computers

SAN FRANCISCO—In years to come, electronics firms will be spending less time developing circuitry and components, and more time designing comprehensive computer systems in which available hardware can be put to best use.

This was the recurring theme of the recent Western Joint Computer Conference sponsored by the Institute of Radio Engineers, American Institute of Electrical Engineering and the Assoc for Computing Machinery. Exhibits emphasized trends, theory and application rather than hardware.

According to Walter F. Bauer of Thompson-Ramo-Wooldridge Corp, computing elements will have to be flexible enough so that the user can fit them into systems designed for the data-processing or process-control problems at hand. Another T-R-W engineer, Charles Kellog, offered the "fact compiler" concept as an example; it would provide an input in unambiguous "restricted English."

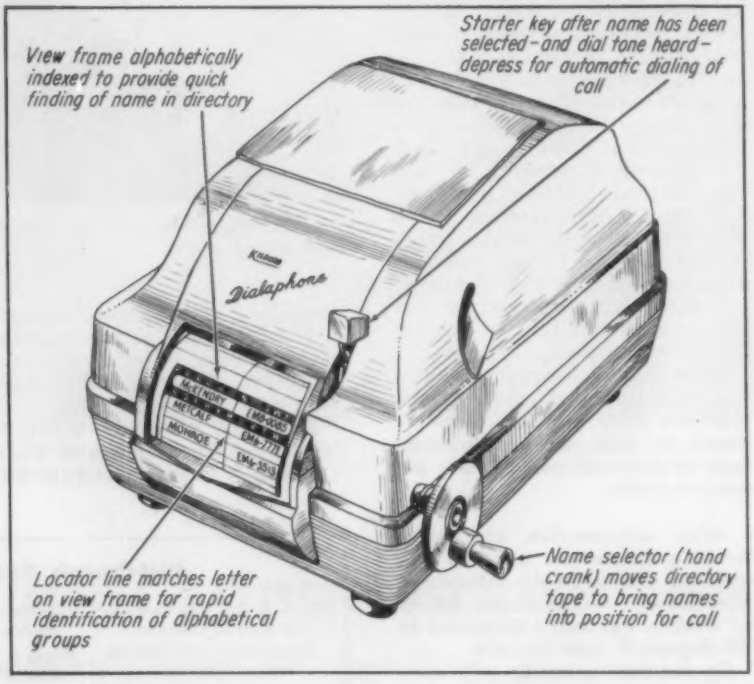
Discussing growing problems of data handling, Robert M. Hayes of Electroda Corp reported that a "great void" exists between manufacturers of computers and users of the equipment. He predicted development of integrated systems that will radically change the present pattern of equipment installation by manufacturers.

"Special systems teams will be created, which, independent of maker and user, will be responsible both for setting up the system and for ensuring that it works afterward," Hayes said.

Big news on the hardware side was Packard-Bell's PB 250 digital computer, a solid-state device described as a standardized system component rather than an autonomous unit. PB 250 is priced at $30,000 with power consumption of 100 watts. ■

Does Its Own Dialing

Called Dialaphone, this innovation enables caller to press a starter key which automatically dials the desired number. As shown at right, caller turns name selector (accomodates up to 850 names and numbers) and after locating desired party's name, presses starter key. Telephone company installs system, which can be adjusted for direct long-distance dialing. Directory tape serves as system's memory; names and numbers can easily be added to or deleted from the tape.


View frame alphabetically indexed to provide quick finding of name in directory
Starter key after name has been selected—and dial tone heard—depress for automatic dialing of call
Dialaphone
Locator line matches letter on view frame for rapid identification of alphabetical groups
Name selector (hand crank) moves directory tape to bring names into position for call

Soviet Educator Reports New Series of USSR Satellites

Moscow—According to a leading academician here, the Soviet Union is planning an entirely new series of artificial satellites. They are expected to bring closer the age of human space travel.

Anatoly Blagonravov said the vast undertaking will assist studies of ultraviolet radiation and X-rays in spectra of the sun and other celestial bodies. It will seek to map stars according to spectral lines and photograph the solar corona and nebulas. The program also provides for further investigation of cosmic rays, structure of earth's magnetic field and its relation to solar activity, degrees of ionization and the composition of ionosphere as well as its condition for radio-wave propagation.

In later stages of the program, the Soviets plan to send special containers of plants and animals to the planets of our solar system to pave the way for human travel in space.

Blagonravov said that space-conquest problems would be solved best if all scientists work together. ■

Lockheed Blames Crashes Cause on Flutter in Nacelle Area

BURBANK, CALIF—Violent oscillations of a wing, combined with structural defects in the outer engine area, caused the two highly publicized in-flight accidents suffered by Lockheed Electras (*PE—May 2 '60, p 15*).

Lockheed engineers report this as a result of the investigation ordered by the FAA into the accidents. With the test program virtually complete, Lockheed expects any additional date developed to confirm the conclusions.

"In our opinion, the accident resulted from dynamic coupling at high speed of oscillatory movements of the outboard power-package, nacelle and the wing," said J. B. McBrearty, assist senior manager of Lockheed California Div, who has been directing the company's inquiry. Explaining further, he said:

"All our tests and calculations substantiate the conviction that some element of damage existed in the power package-nacelle area of both Electras prior to their accidents. This damage by itself could not have caused destruction. Each airplane encountered an additional external force which also by itself could not have caused destruction. But the combination of the broken or weakened element, plus the external force intensified by high speed, acted as a 'trigger' to set off oscillations, and built up the forces to the breaking point."

Though McBrearty said Lockheed is "reassured that modifications can be installed to prevent accidents from occurring from such combinations," it is expected that such design modifications will cost about $25 million before normal flight speeds can be resumed. (FAA has restricted Electra speeds to 260 mph maximum.)

The aircraft company earlier had presented its conclusions to representatives of the FAA. Final determinations of probable cause of the accidents lie with the CAB, but McBrearty said he was sure the program of improvements Lockheed is now developing would encompass any official findings of exact causes. ■

New Light-dimmer to Cut Industrial Power Costs 30%

CHICAGO — A 1½-lb light-dimmer, which promises to cut industrial power bills 30%, has been demonstrated here by International Research Associates. The unit controls up to 12,000 watts and draws only enough power for a desired light level—contrasting with conventional light-dimmers that convert unwanted lighting power into wasted heat.

In operation, the dimmer is connected between power main and load lights. A single control is preset to the desired light level. A photocell checks light level in the areas; when ambient light decreases to the present level, lamps are turned on gradually, maintaining the selected light level within two foot-candles. The small package will control 12,000 watts (ac, resistive or inductive) at any point between full on and full off; load-circuit shorts or opens cannot damage the device. The control circuit itself draws less than one-half watt. Six-week delivery time is quoted by the manufacturer.

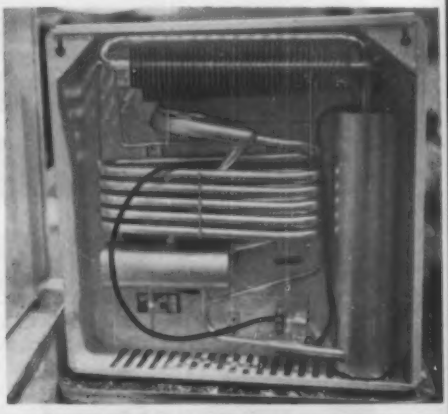
Only static or solid-state components are used. ■

US Trade Mart Features Exhibits from 66 Lands

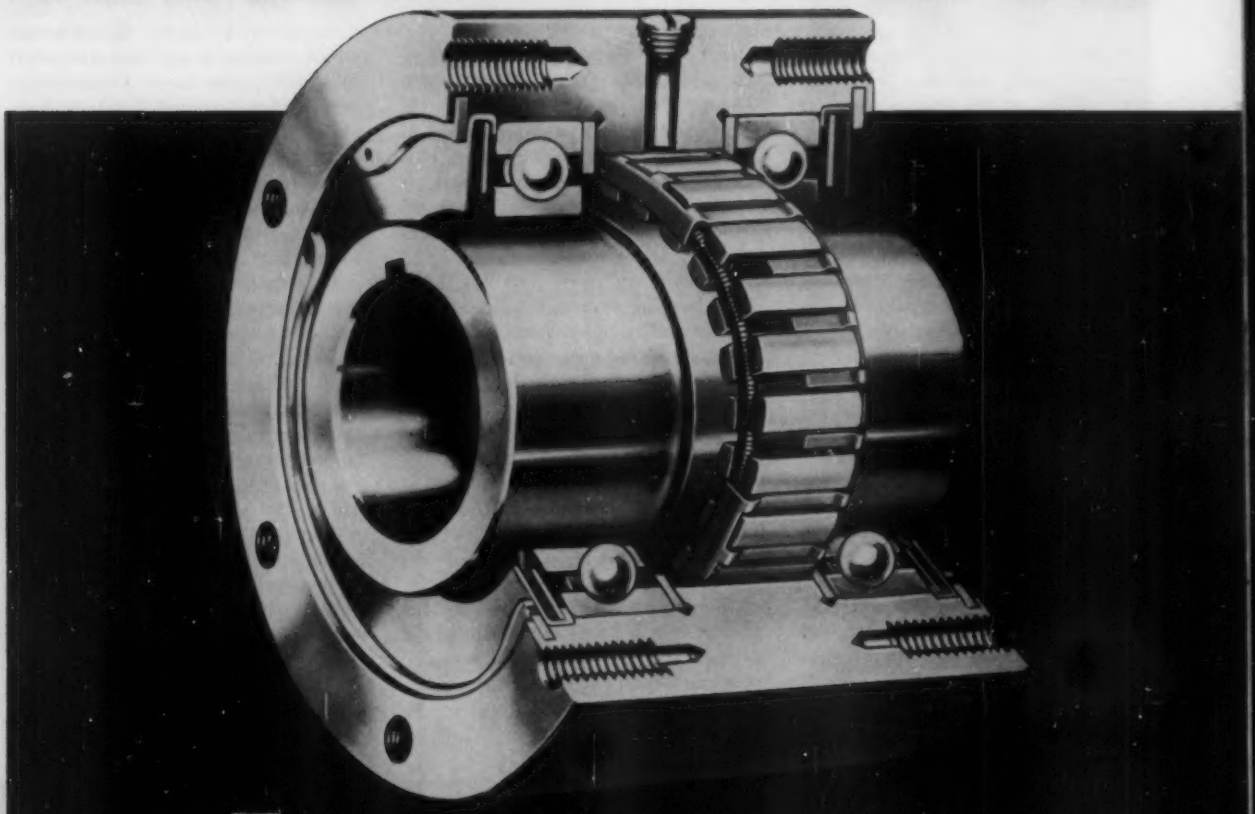
Refrigerator without moving parts, right, is among displays at New York's 4th World Trade Fair. These compressorless, motorless "absorber" machines remove heat from the cabinet by a heating-condensation cycle of ammonia. The ammonia and water solution for this cycle is contained in a large cylinder (upper photo, far right).

The deep box shown here, 19 in. high, 19 in. wide, 21 in. deep, is produced by the West German firm, Uropa International Inc. Its capacity is 1.6 cu ft and it operates on 110 volts ac-dc. Models operating on 12 v for cars or boats are also available.

The Sabra, Israeli sports car at bottom, combines (far hight) a 4-cyl, overhead-valve, watercooled engine made in England, with a fiberglass body made in Israel. The vehicle is assembled by Autocars Co Ltd of Haifa; will be marketed in the US late this summer for about $3000.



The OVER-RUNNING CLUTCH With

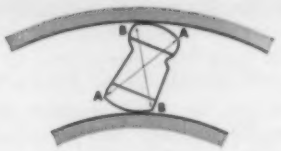


OVER-RUNNING · INDEXING BACKSTOPPING

STANDARD CLUTCHES FOR ORIGINAL EQUIPMENT NEEDS

Formsprag Clutches are used throughout industry, from business machines to aircraft, in bore sizes from ¼" to 12". Several informative bulletins available, including: "Design Considerations for High-Speed Over-running Clutches," "Ten Design Ideas", "Seven Ways to Reduce Space and Costs", plus the complete Formsprag catalog. Write for any one or all.

HERE'S



The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

Greatest Torque
Per Inch – Per Ounce

Modern power transmission design demands the utmost torque capacity in an absolute minimum of space. That's why designers in every field specify Formsprag clutches . . . the *modern* way to transmit power on over-running, back-stopping and indexing applications.

Along with highest possible torque capacity for its size and weight, every Formsprag clutch offers such additional benefits as internal simplicity (just four basic parts), no measurable backlash, light weight, compactness, extreme precision and long, trouble-free life. Formsprag's exclusive, patented principle is unlimited in application, yet this full-complement sprag type clutch is extremely simple in design and operation.

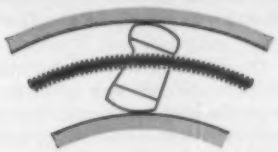
There is a size and model Formsprag clutch for every application. Standard models include sleeve bearing, ball bearing, miniature, and large bore backstop types. These are shown in the current Formsprag catalog, complete with specifications, performance data and design suggestions. Ask your Formsprag distributor, or write direct for your copy. For special applications, Formsprag engineers will recommend a modified standard or design a special. Send details of your requirements.

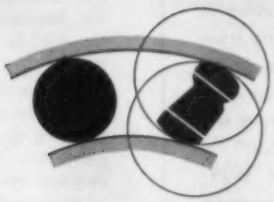
FORMSPRAG COMPANY
23607 Hoover Road, Dept. 104
Warren (Detroit), Michigan

In Canada: Renold Chains Canada, Limited
In United Kingdom: Renold Chains, Limited
Distributors in Principal Cities

FORMSPRAG CLUTCHES
Precision Power Transmission Products

HOW IT WORKS



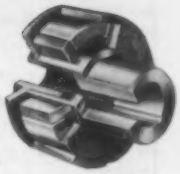


An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

OTHER FORMSPRAG PRECISION PRODUCTS

RAWSON Centrifugal Clutches



No-Load Motor Starts. Cushioned Starting of High-Inertia Loads, Overload Protection.

REVILOK

Dual Torque-Locking and Positioning Device Eliminates Feed-back Torque, Provides Two-Directional Drive, Positioning, Over-running and Backstopping.

POINTS OF VIEW

THE QUESTION:

What Has the Missile

Dr ALLEN V. ASTIN, Director
National Bureau of Standards

The National Bureau of Standards is charged with the responsibility of establishing and maintaining the primary standards of physical measurement of the United States. The man shouldering this responsibility is the Bureau's director, Dr Allen V. Astin. His following review of present-day problems was given exclusively to Product Engineering's Washington editor.

■ The missile age has meant increased requirements on components—the only means of determining how good they are is to get adequate measurement facilities. The 1961 budget contains a request for $23.5 million for construction of new mechanical test facilities. We are very hopeful that Congress will make the necessary appropriations.

Part of the money would be spent for a 1-million-lb deadweight machine. Its primary use would be to improve calibration accuracies for measuring the thrusts of large rocket engines. Industry, for example, wants accuracies down to 0.01 to 0.02 per cent. Right now, this is about 10 times more accurate than what we can give them. With the new machine, however, we could achieve the necessary accuracies.

Proper measurement is essential to achieving proper reliability. The Aerospace Industries of America Assn, for example, recently found 150 areas where there was a need for better measurements than we currently have the ability to perform.

Who Is Ahead in Technology, the US or the Russians?

In all areas that I know of, we are at about a standoff with the Russians, except in high-temperature measurement. In this field, they are ahead of us.

From what I have read, and from talking with scientists of other countries who have visited the Soviet Union, it appears that they can measure temperatures up to several thousand degrees Farenheit fairly accurately. As much as two years ago, the Russians were said to be able to measure temperatures in the 9000 to 11,000 F range, and were striving for the 21,500 F range.

Two to three years ago, the US could measure temperature only in the 3500 to 5500 F range. We are now in the process of trying to design some super facilities to measure heat from 18,000 to 27,000 F. We can now reach 27,000 F for research purposes only. So far, however, we have not had a request to measure at this level.

Does the Bureau of Standards Have Adequate Facilities to Handle Its Workload?

No, we need new facilities; we are a long way from having what we ought to have. In the past two to three years, we have had some relief, but, during the four years before that, appropriations declined. This year, fiscal 1960, we have essentially the same staffing level as we had back in 1950. We expect to have some new facilities in about five years. The first units

Dr Allen V. Astin has always been interested in the problems of measuring. After graduating from the University of Utah he accepted a teaching fellowship at New York University, where his doctoral thesis was "New Method for Measuring the Dielectric Constants of Conducting Liquids." It was published in the *Physical Review* in 1929; two years later, Dr Astin became a research associate with NBS. In the 1940s he took a leading part in the development of the radio proximity fuse and was awarded the Presidential Certificate of Merit and the Kings Medal (England). Dr Astin became associate director of the NBS in 1951 and within two years was appointed director by President Truman.—SP

Age Meant to the Bureau of Standards?

will be installed at Gaithersburg, Md, where the Bureau will be moving in about 2 to 2½ years. The new, more spacious facilities at Gaithersburg are designed for about 20 percent larger staff. The heat division is slated for the largest expansion.

Where Are the Technical Bottlenecks for Space-age Developments?

One of the biggest is learning how to measure heat accurately. The most confusion exists in the range from 10,000 F to two million F. One of our prime objectives is to bring order to this field.

What About the Future?

We must ultimately learn to measure temperatures in terms of millions of degrees. But, it is impossible to say when this will be done.

We must also learn about the properties of extremely pure materials and how to design with them. We are learning more about materials and oxidizers for use at high temperatures. Ultimately, we must also exploit the properties of materials at extremely low temperatures. Quartz crystals, for example, become superior frequency-control devices at cryogenic temperatures. And masers, operating at these temperatures, have very intriguing properties as energy detectors.

Does the Bureau of Standards Plan to Establish More Calibration Stations Around the Country?

No, our plan is to stimulate the calibration capacity of other organizations—industry and the Department of Defense, for example. In addition, we have to do more educating about the need for accurate calibration. A number of engineers seem to have a curious blind faith in the printed scales on an instrument.

How Will NBS Stimulate Department-of-Defense and Industrial Calibration Capacities?

The Bureau is increasing its publication activity to provide more helpful information on Bureau calibration services and capability; on techniques of calibration to be used in industrial and military calibration centers; and on calibration equipment. The Bureau is also attempting to provide more direct advice to organizations seeking to improve their calibration services. This is being done by more frequent visits, both of Bureau personnel to industrial laboratories, and of industrial engineers to the Bureau's laboratories. In addition, the Bureau is studying the possibility of enlarging its advisory committee in order to deal more directly with the defense-industry calibration problem.

Must All Instruments Be Calibrated at NBS or Against NBS-calibrated Instruments?

There is no requirement that instruments should be calibrated against NBS-calibrated instruments or standards, except in certain military programs where the Department of Defense has established such a requirement. Such a requirement would be unwise and would overtax Bureau facilities and tend to divert NBS from important research programs. On the other hand, it is important to develop increased appreciation of the necessity of relating measuring instruments to national standards whenever measurement data taken at one spot must be compatible with measurements in other locations. In most instances the instrument manufacturer should be able to provide assurance that his instruments are consistent with the national system of measurement.

What New Things Do You Think Industry Wants from the Bureau of Standards?

In the field of measurements, industry wants an extension of accuracy and range; and it wants new types of calibration. For example, industry would like to have instruments that measure the mass-flow rate. This would meter the mass of material, rather than the volume-flow rate. Industry would also like to have calibrations of new radioisotopes, and certification of properties of single crystals.

Have Certain Standards Like the Johanssen Gage Been Obsoleted by Our Improved Technology?

No, they are more useful than ever because there are more instances when they are needed. The only respect where such standards become obsolete is where very precise control is required. New gage blocks are being developed, using new materials that have considerably more dimensional stability. Such materials as special steel alloys, and ceramic materials are being looked at. We would still use the old gage blocks for routine work, reserving the new ones for the most exacting requirements.

Do You Think the US Should Adopt the Metric System??

In a sense, the US has adopted the metric system—its use is legal and it is widely used in many activities, particularly in scientific investigations. The queston undoubtedly refers to the greater or perhaps exclusive use within the US of the metric system. On this problem I believe the National Bureau of Standards should neither advocate nor oppose increased or exclusive use of metric measures, but should be prepared to provide measurement services in either metric or conventional units. The Bureau's goal of promoting accurate and uniform physical measurement can be accomplished in either system. On the other hand, I believe we will encounter increasingly difficult problems in the field of international trade because virtually the entire world, except the English-speaking countries now use metric measures exclusively, or is in the process of converting to them. In connection with this problem, I believe the National Bureau of Standards can be helpful in developing information to help segments of industry decide whether or not to adopt metric measures for its operations.

What Portion of NBS's Budget Is Spent for Basic Research?

Approximately 50% of the Bureau's appropriated operating funds is devoted to basic research. The Bureau could do more basic research if time and facilities were available. Most of the Bureau's basic research is supported by direct appropriation from Congress, not by funds from other agencies. ■

ARMCO STEELS for better products – lower costs

HOW ARMCO 17-4 PH SOLVE THESE DESIGN AND

High Strength Plus Corrosion Resistance

Until a relatively few years ago, lack of a stainless steel that combined exceptionally high strength with excellent corrosion resistance forced design compromise. Manufacturers had to accept the limitations of standard stainless grades, plated low-alloy steels or use expensive non-ferrous metals. Then Armco 17-4 PH* Stainless filled this void with typical ultimate tensile strength of 200,000 psi, and corrosion resistance comparable in many media to Type 302 stainless. Manufacturers are now using this unique material for parts such as shafts for pumps, compressors, and specialty motors; studs; fasteners; and valve stems.

*Trademark

Adequate Strength at Elevated Temperatures

Higher operating temperatures and stresses in chemical processing, aircraft, nuclear reactors and other industries create the problem of finding metals with adequate properties. With typical short-time ultimate tensile strengths of 169,000 psi at 700 F, 149,000 psi at 900 F and excellent corrosion resistance, Armco 17-4 PH Stainless Steel has solved this problem in many applications. At temperatures up to 1000 F it has creep, stress-rupture and short-time tensile strengths superior to any of the standard stainless grades. Valve parts, control shafts, fasteners, aircraft components are typical 17-4 PH stainless applications.

Use the unique properties of Armco 17-4 PH Stainless Steel to give **your** products superior performance at low cost. Write us, or mail the coupon, for complete information on this special, easy-to-harden stainless steel. It is available in bars, wire, and billets. Armco Steel Corporation, 2030 Curtis Street, Middletown, Ohio.

New steels are born at Armco

Send me complete information on Armco 17-4 PH Stainless Steel. We are considering it for these applications:

Name_____

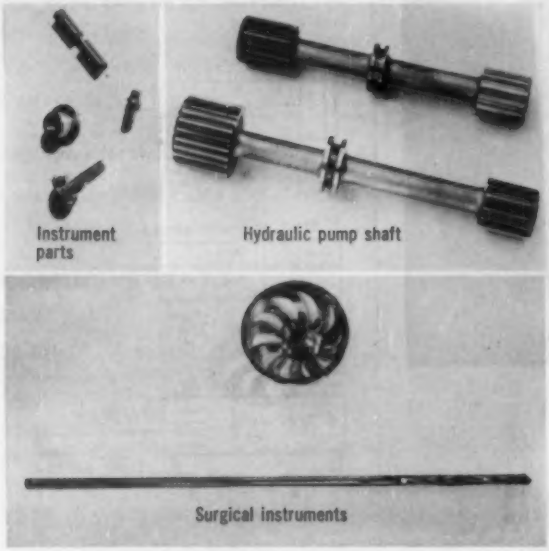
Company_____

Street_____

City_____ Zone____ State_____

STAINLESS STEEL HELPS PRODUCTION PROBLEMS

Elimination of Distortion and Scaling



Heat treatment of standard hardenable stainless grades and low-alloy steels causes extensive distortion and scaling that requires additional expensive shop operations. Armco 17-4 PH Stainless Steel eliminates all these because it requires only a simple low temperature heat treatment. Hardening at about 900 F for 1 hour or more does away with troublesome distortion and produces only a light heat tint that does not affect dimensional tolerances. Consequently, parts can be completely finished, then heat treated. Tempering, straightening, pickling, and secondary finish machining are eliminated.

Resistance to Galling, Wear and Abrasion

By combining high hardness, up to Rockwell C44, with excellent corrosion resistance, Armco 17-4 PH offers a solution to many galling, wear, and abrasion problems. Formerly, some compromise was necessary because of the limitations of standard stainless grades or expensive high alloy metals used. Now many parts requiring a corrosion resistance approximating that of Type 302 can be given galling and wear resistance that means longer maintenance-free operations. Typical applications where Armco 17-4 PH Stainless results in superior service include studs, pump shafts, valve parts, wear rings and mixer shafts.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

CIRCLE 27 ON READER SERVICE CARD

COOPERATION
produces the final design!

Cooperation is the key to any product. One man, perhaps you, has the responsibility for adding ideas and correlating the work of others to develop a superior design. Rockford Clutch has designed and supplied clutches for hundreds of products . . . let them help you. Their recommendations are without obligation and they are recognized leaders in the field of clutch design and manufacture. Whether it's a clutch for a motor truck, lift truck, bus, tractor, lathe or other equipment—call or write for recommendations on the Rockford Clutch to fill your needs.

ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION BORG-WARNER

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ROCKFORD, ILLINOIS

Export Sales
Borg-Warner International
36 So. Wabash, Chicago, Ill.

READER TO EDITOR

Air-cushioned Cylinder

To the Editor:

For your interest, here is a drawing of the power cycle of an air-cushioned cylinder as used by our organization.

Fig I through IV will explain and show the most effective and simplest system of cushioning; control and stability are its good points. This system has been in effect for over two years with almost no service or attention. The possible two million cycles made by one such device over this period are the proof of its capability.

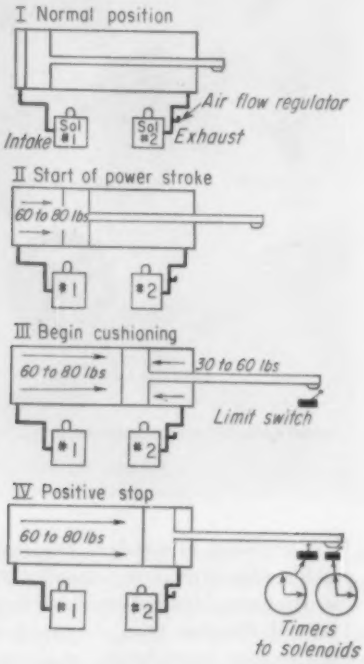


Fig I shows the power cylinder in the normal position, waiting for a signal from the main control panel to start its power drive. As you can see there are two solenoids, the drive and the cushioning, marked "intake" and "exhaust." A third "Master" solenoid (not shown) operates as a safety measure and a fine control. It is opened during the normal run, but closed when the circuit switch is off. It is also used to control other similar systems in the same line in the event of a breakdown.

Attached to the exhaust solenoid shown is a small "airflow regulator," used for fine control, but not necessary for the system to operate properly.

Fig II shows the power cylinder receiving air from the activated solenoid #1; thus starting the high-pressure power drive.

Fig III. At a chosen point of the power stroke, a limit switch is activated. At this point one can allow the cylinder to "coast" part way with no pressure on either side. This is not the normal practice, but is occasionally used for lightweight opera-

tions. The signal causes air to enter the system from the exhaust side through the air reducer causing the cylinder to slow to a near stop.

Fig IV. A few inches (or less) from the end of the stroke, the exhaust is cut off by a timing device and the intake pressure bottoms the cylinder against a solid stop. This bottoming action will not break down the cylinder, because the cushioning is at a maximum pressure at this time.

When the intake has been timed out, (by the second limit switch) the exhaust takes over and returns the cylinder to the normal position.

As can be seen, this system is simple, effective, and easily controlled. This information may be of help and interest to your other readers.

—Bob Yuhas
Wickliffe, Ohio

Correction

In the April 17 issue, p 60, we incorrectly listed the manufacturer of ultrasonic filter-cleaners. It should have read: Pall Cavitron Corp, Glen Cove, NY.

COMING EVENTS

MAY

23-26 . . . American Society of Mechanical Engineers, Design Engineering Conference, New York Coliseum, NYC

23-26 . . . Clapp & Poliak, Design Engineering Show, New York Coliseum, NYC

23-26 . . . American Institute of Electrical Engineers, Instrument Society of America, American Rocket Society, Institute of Aeronautical Sciences—National telemetering Conference, Marimar Hotel, Santa Monica, Calif.

JUNE

10-26 . . . British Exhibition, New York Coliseum, NYC.

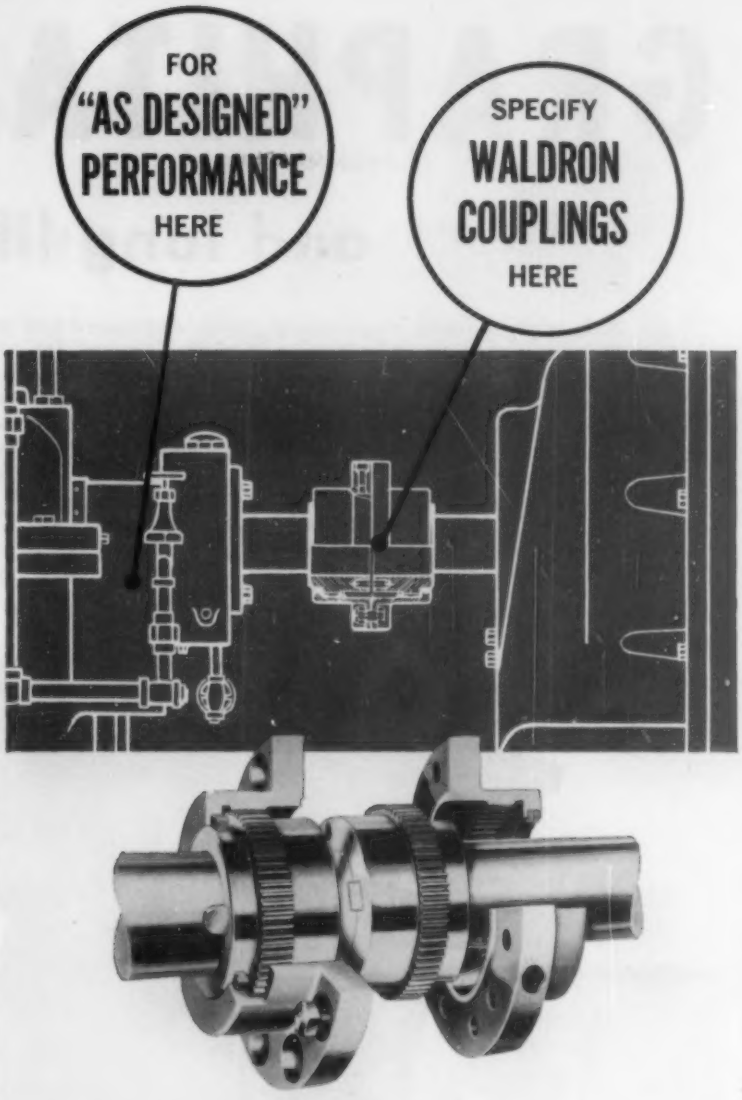
13-15 . . . Metal Powder Industries Federation and American Institute of Mining, Metallurgical & Petroleum Engineers, jointly sponsoring International Powder Metallurgy Conference, Hotel Biltmore, NYC.

19-21 . . . Alloy Casting Institute, Annual Meeting, The Homestead, Hot Springs, Va.

20-24 . . . American Society for Engineering Education, Annual Convention, Purdue Univ, Lafayette, Ind.

26-July 1 . . . . American Society for Testing Materials, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, NJ

27-29 . . . Institute of Radio Engineers, 4th National Convention on Military Electronics, Sheraton-Park Hotel, Washington, DC.



When a lot of time and effort have been put into the design of a driven unit, it makes sense to protect its operating efficiency wtih a good coupling.

Waldron gear couplings are available in a wide range of standard and special types for any service requirement, to provide complete protection and positive, trouble-free drive.

Deliveries are excellent. Rough bore standard couplings up to 6" sizes, already assembled, can be shipped from stock; others, to meet customers' schedules.

WALDRON Couplings

WALDRON-HARTIG DIVISION *Midland-Ross Corporation*
P. O. Box 791 · New Brunswick, New Jersey

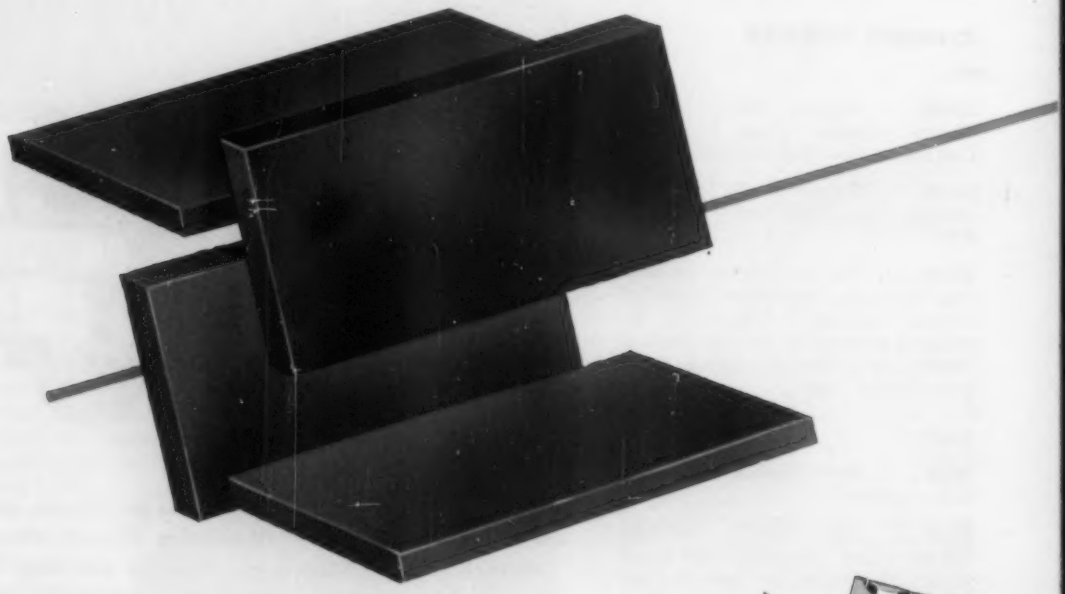
CIRCLE 29 ON READER SERVICE CARD

GRAPHITAR® VANES

(CARBON-GRAPHITE)

and long life of CONDE

This rotary positive displacement pump, engineered and produced by the Dri-Air Pump Department of the Conde Milking Machine Company, Inc., of Sherrill, N. Y., is designed to deliver clean, dry air or gas for high vacuum and low pressure applications in hospitals, dental offices, chemical or pharmaceutical plants, industrial processing systems and in metalworking plants. Thanks to vanes of GRAPHITAR, the CONDE Dri-Air Pump gives years of trouble-free, continuous operation at maximum recommended vacuum and speed . . . *without lubrication!* The GRAPHITAR pump vanes are self-lubricating and are seated by centrifugal force. Operating with a minimum of friction, they become increasingly efficient as the pump is used. In addition to their self-lubricating properties, the GRAPHITAR vanes are hard, light, non-sticking, non-warping and chemically inert. Perhaps these qualities can be utilized to advantage in your products.



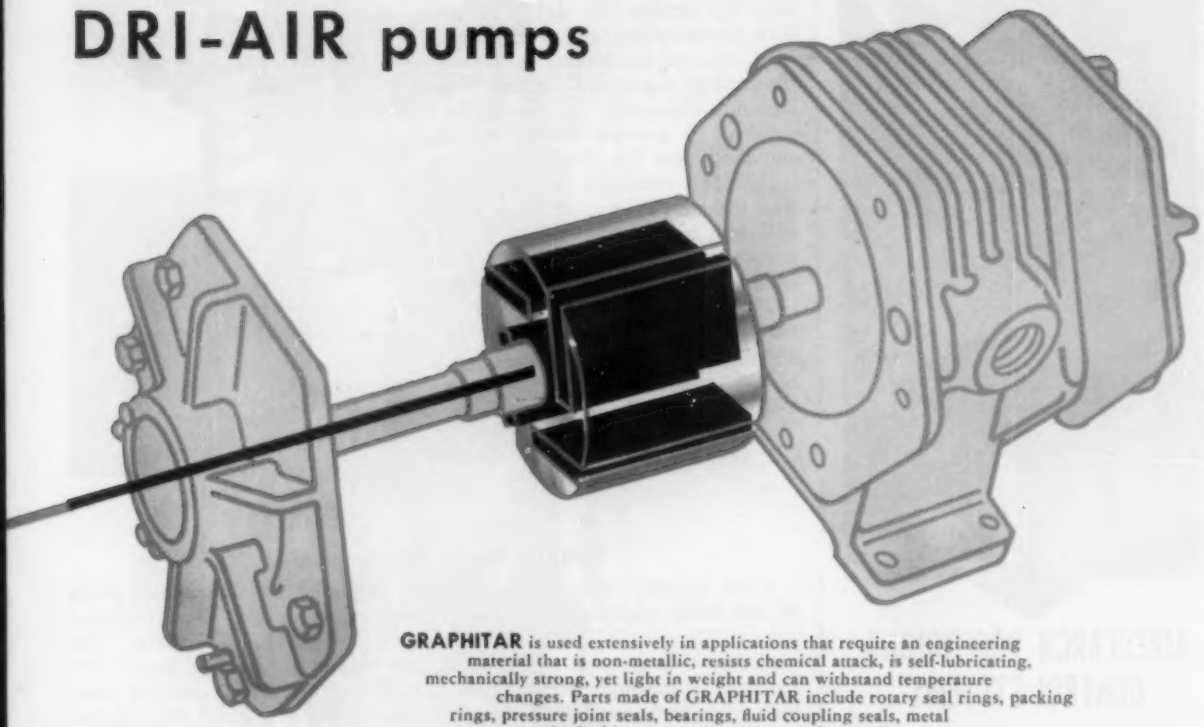
Bulletin #20 includes detailed design data along with properties, characteristics and typical applications of GRAPHITAR. Write for your free copy. If you have questions concerning the incorporation of GRAPHITAR parts in your products, our engineers will be glad to assist you.

THE UNITED STATES

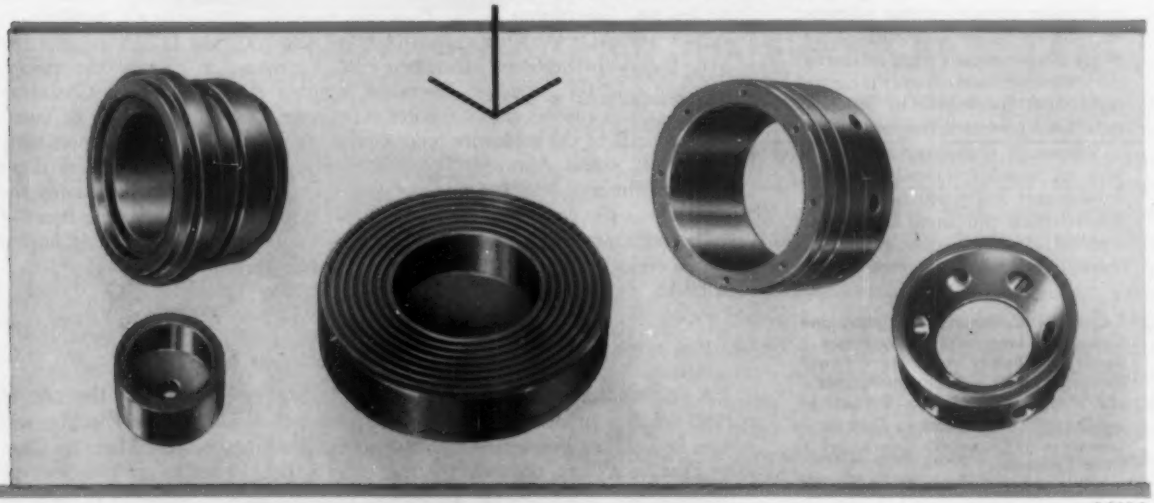
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

help insure efficiency

DRI-AIR pumps



GRAPHITAR is used extensively in applications that require an engineering material that is non-metallic, resists chemical attack, is self-lubricating, mechanically strong, yet light in weight and can withstand temperature changes. Parts made of GRAPHITAR include rotary seal rings, packing rings, pressure joint seals, bearings, fluid coupling seals, metal backed bearings, piston rings and pump liners.



R-285-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

Electromechanical
Components and Systems
Capability

AIRESEARCH POSITIONING CONTROL SYSTEMS

One of the many types of high speed positioning control systems produced by AiResearch, the system above amplifies electric signals from an inertial guidance source and adjusts the control surfaces of the missile or drone to maintain a predetermined course.

AiResearch diversification and experience provide full capability in the development and production of electromechanical equipment and avionic controls for aircraft, ground handling, ordnance and missile systems.

A.C. and D.C. Motors, Generators and Controls • Inverters • Alternators • Linear and Rotary Actuators • Power Servos • Hoists • Electrical Pyrotechnics • Antenna Positioners • Positioning Controls • Temperature Controls • Sensors • Williamsgrip Connectors • Static Converters.

Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

FOR YOUR INFORMATION (personal)

Billy goes electronic

You'd hardly recognize the old shillelagh these days. The familiar billy club of the policeman has been transmogrified into an alarm-signaling device for guards and watchmen. It operates much like the personal paging systems now in wide use. A built-in, concealed, transistorized transmitter powered by a 6-volt rechargable miniature accumulator does the job.

Pressing a concealed button at the top of the stick transmits a signal, which is picked up by an induction loop aerial surrounding the area to be protected. This operates a small receiver which automatically switches on the alarm.

The device is manufactured in England (where billy clubs are called truncheons) by Multitone Electric Co Ltd, 12/20 Underwood St, London N 1. Canadian distributor: Multitone of Canada Ltd, 24 Merton St, Toronto 7, Ont. Price (FOB Toronto or Buffalo): $145 for the truncheon itself; $445 for the receiver and charger.

Tektites tease theory-makers

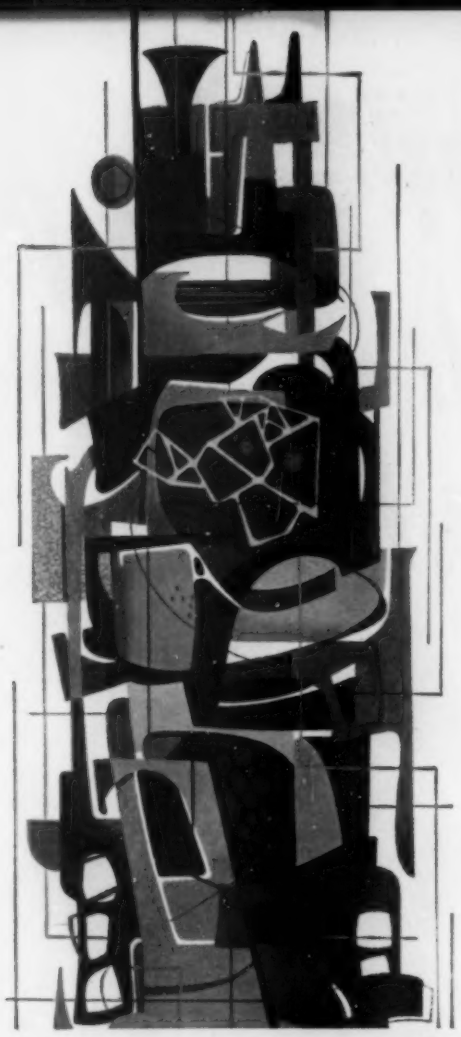
A real scientific controversy is beginning to boil around a few small pieces of rock found—some of them over a century ago—in such widely scattered areas as Moravia and the Dutch East Indies. Their name: Tektites. The dictionary defines them simply as "glassy bodies of unknown origin, and rounded but indefinite shape." But early this year, an NASA scientist traced their origin to the moon. They were, he said, pieces of material either ejected from the moon or pulled from it by the earth's gravitational force, then melted and fragmented during their trip to earth (PE—Apr 11, p 32).

Now come Dr W. O. Ehmann of U of Kentucky and J. Zahringer of the Max Planck Institute of Heidelberg, W. Germany, to dispute the theory. Ehmann told the American Chemical Society's Div of Inorganic Chemistry that chemical analysis shows tektites contain far too little nickel to be outer-space objects of the meteorite type, though he did not rule out the possibility completely. And Zahringer reported that radioactivity measurements don't jibe with the moon-drop theory, either. He found samples to be roughly the same age as the geological deposits here on earth in which they were found—indicating a similar, concurrent, terrestrial origin—perhaps by meteoric impact terrific enough to melt just about all the surface rock in the area.

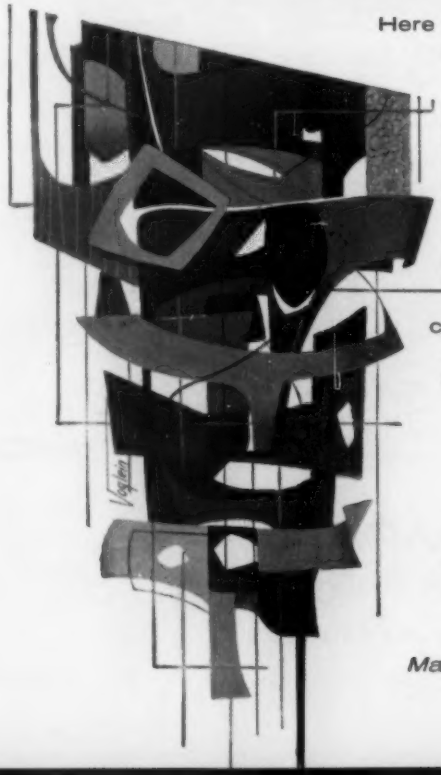
How fast can you talk—or type?

A communications system that transmits teletype messages at the rate of 1000 words a minute is going into operation at Westinghouse Electric, will soon be installed in several other company and military offices. Made by Crosley Div, Avco Corp, the system is said to be 3 times as fast as ordinary teletype transmission. It uses a 2-speed magnetic recorder to take messages at standard rate (60 to 100 wpm) and then transmit them at high speed. A similar unit at the receiving end reverses the process. The units are transistorized, weigh about 150 lb, can be hooked up to standard paper and tape transmitters and, Crosley says, will store up to 12 hr of message information. Although the system uses regular telephone lines instead of the less-expensive teletype wires for transmission, its developers expect it to be a money-saver as well as time-saver.

—ARG



AS YET WE HAVEN'T SCRATCHED THE SURFACE



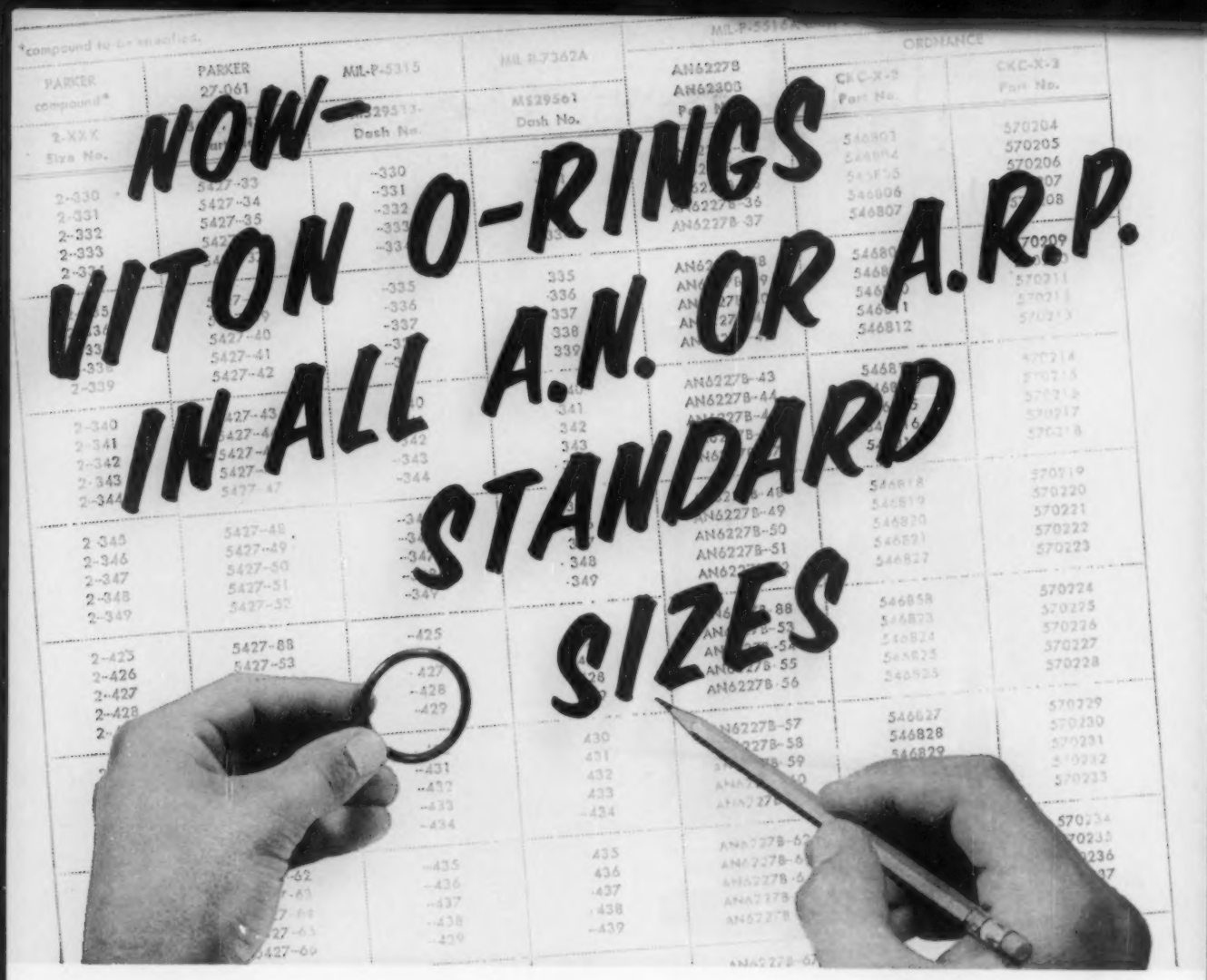
Here is material that sets a designer to dreaming . . . **versatile, durable cast aluminum.** Its form is bound only by the dimensions of design. Special finishes . . . including the dramatic beauty of porcelain enamel . . . inspire artistic treatments of surface textures. Here, then, is your opportunity for creating products never before interpreted in cast aluminum . . . opportunity for redesigning new appeal into existing products. Monarch exploratory engineering in new aluminum casting techniques, Monarch facilities for product development and manufacturing can contribute to your sales expansion and product leadership. Write R. A. Lawson, Vice President–Marketing.

MONARCH ALUMINUM MFG. COMPANY

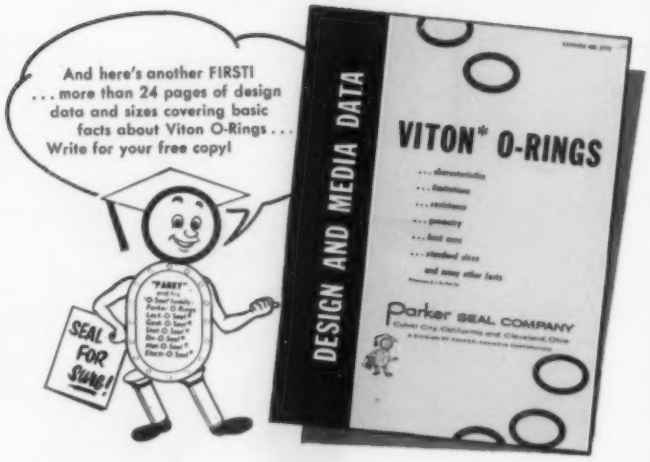
9205 Detroit Avenue • Cleveland 2, Ohio

Manufacturing Achievements in Molten Aluminum

NOW— VITON O-RINGS IN ALL A.N. OR A.R.P. STANDARD SIZES



One of the first to embark upon a research and development program for Viton O-rings, Parker Seal Company now makes another significant advance in this versatile high temperature material by offering Viton O-rings in all A.N. or A.R.P. standard sizes. This means faster delivery and greater economy for all these popular O-ring sizes. It's another plus result of **responsible leadership** *in O-ring engineering by Parker.*


And here's another FIRST! . . . more than 24 pages of design data and sizes covering basic facts about Viton O-Rings . . . Write for your free copy!
SEAL FOR SURE!
DESIGN AND MEDIA DATA
VITON* O-RINGS
Parker SEAL COMPANY

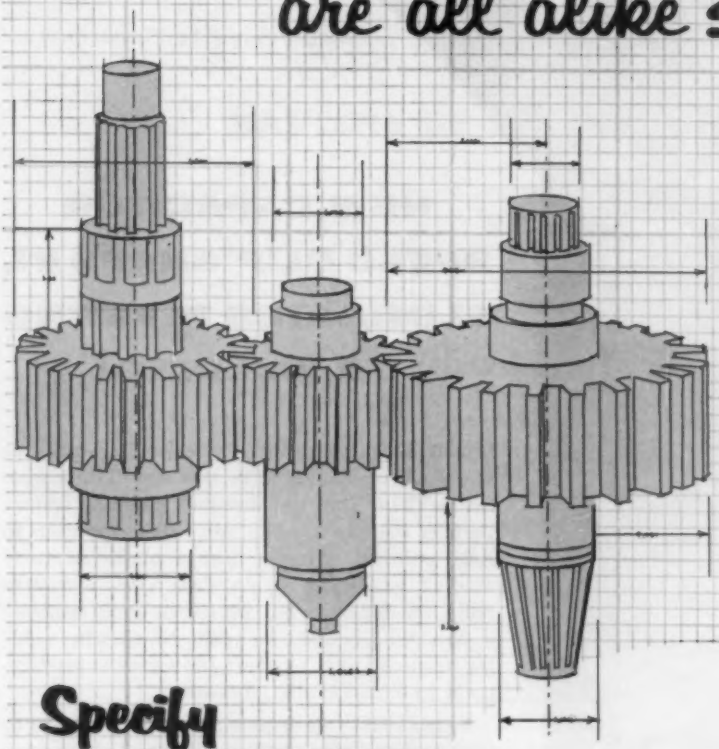
Parker SEAL COMPANY

Culver City, California and Cleveland, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION

CIRCLE 34 ON READER SERVICE CARD

Who says Shafts are all alike?



Specify

US®

Custom-Engineered SHAFTS

—with "extra-duty" toughness built in!

YOUR PRODUCT NEEDS the ultra-dependable performance of U.S. Shafts in every application. Precision-made to your exact requirements, U.S. "Custom-Engineered" shafts provide important "extras" for longer-lasting, trouble-free service. *Extra quality* from finest alloy steels . . . *extra skill* from 40 years of specialized know-how . . . *extra durability* from heat-treating and shot-peening processes. Whatever you design with a shaft, design it *best* — with U.S.!

Submit your prints and specifications for prompt quotation.

FREE — valuable brochure about U.S. Axle — your best source for custom-engineered shafts

THE WORLD TURNS ON U.S. AXLES

THE US AXLE COMPANY, INC.

Since 1920 • Pottstown, Pennsylvania

Engineered by Tinnerman...

NEW CAPACITOR SPEED CLIP® SNAPS IN, ELIMINATES RIVETING OR WELDING!

Speed up the assembly of capacitor clips to electronic equipment with this new Tinnerman SPEED CLIP. The "heel-and-toe" fastening feature permits the clip to slide into locking position in holes punched in metal, fiber or plastic as easily as your foot slides into a shoe. Once locked in place, the clip stays put, yet can be easily removed and reused over and over again. No riveting, welding or special tools required—no screws to start, no parts to loosen under vibration!

SPEED CLIPS can be provided in various sizes to hold capacitors and other cylindrical parts from $\frac{3}{8}$" to $1\frac{1}{2}$" in diameter and to fit a wide range of panel thicknesses.

Samples and prices of these SPEED NUT brand fasteners are available from your Tinnerman sales engineer. If he isn't listed in your Yellow Pages, write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 2 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

May 23, 1960

MASTERS OF DESIGN

In medieval Europe, as early as the twelfth century, there were organized guilds (really *gilds*) of craftsmen, master workers at their trade or profession. They established apprenticeship, had wardens who maintained standards of good and honest workmanship. In those early days, the candidate member had to produce a test piece of superlative quality. It was called his "masterpiece" (original German word: Meisterstück)—because it gave him the right to call himself a master smith, mason, carver, sculptor, or whatever.

These guilds were also called "misteries," from which we probably get "mastery" as well as our title of "mister." The word "master" survives largely on shipboard, in the Army, in special British titles and in our "master of ceremonies." It is less common in "schoolmaster" and in "Old Master." And the word "masterpiece" now means the equivalent of the French "chef d'oeuvre"—the finest piece an artist produces.

Somehow, as I write this, I wish the old meanings survived. Because, in this issue, we are recognizing a group of masterpieces. Each is the product of several men, rather than one, but it has the characteristics of the old-time masterpiece, and has been so designated among its fellows by a jury of acknowledged "wardens." It is a present-day product that combines the attributes of first-class engineering design and excellent appearance, and it has been accepted in the marketplace.

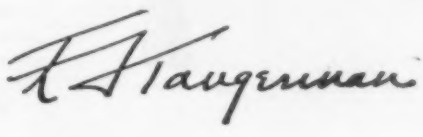
These 11 products have been selected from among 96. Six distinguished judges made the choices: two engineers, two designers, two design educators. While the award winners are the products of particular manufacturers, the certificates of achievement go not to the company but to the individuals most responsible—to men who are readers as you are. And in the guild tradition, the products are not rated one against the other—each has equal rank as a masterpiece.

A great variety of 1959 products—from a baby-food warmer to an automobile—were entered in the 1960 award program, although it was not announced until early in January and entry deadline was February 29. The concept of the program grew out of two merged ideas—our belief that the creative individual is too likely to be swallowed up or neglected in our technological society, and the favorable response a year ago to a PRODUCT ENGINEERING article selecting outstanding designs at the Design Show.

Our effort here has been, and will be, to provide recognition of, and an exhibition place for, masterpieces of mechanical design, selected by a different regional jury each year. The program is open to any mechanical product in the year of its introduction, with no limitations on, or relative rating of, winning entries. The product itself is the only criterion.

It is proper here to extend our thanks to the judges for the time they have given to evaluating entries, and to Jack Kolb, associate editor, who has been directly in charge of development of the program.

It is also most fitting to extend our congratulations to America's master designs of 1960.



96 ENTRIES IN 96 IDENTICAL FOLDERS. The judges read, looked, voted; then defended or abandoned their choice.

"SOME OF THESE I'd like to give a demerit to, I can tell you that right now . . ."

"I LIKE THE SIMPLER THINGS—It takes more ingenuity to design something simple . . ."

JUDGES CHOOSE 11 MASTER DESIGNS

■ It took all day—from before ten in the morning, through lunch, and well into the afternoon. At the end they were satisfied. The six-man panel had judged well and truly. PRODUCT ENGINEERING had its first annual winners of Awards for Achievement in Product Development.

We received 96 entries. Of these, 26 were disqualified for failure to meet entry requirements (Date first offered for sale? Who were the individuals chiefly responsible?). Some were disqualified with considerable regret. The judges said, "If the designers don't treat their entries with the same attention as the products they design . . ." But even the products themselves showed this same carelessness at times. Commented the judges: "Today's 'sense of urgency' sometimes precludes a sense of pride in design, in workmanship . . ."

Of the 70 remaining, 11 were singled out for awards. Each winner received the votes of 80% or more of the eligible judges (in two cases a judge disqualified himself and refrained from commenting because of company connections with the entry manufacturer). The 11 winners are pictured and described in the following pages. For identification of the judges, see page 3.

The Basis of Choice

Part of the excellence of any product is its immediate and obvious appeal and understandability—not, necessarily in *how* it functions, but in *what* it does. This is essential to success in the marketplace, whether the market is a store counter or a component manufacturer's catalog.

The judges: "Sound design *looks* better, it looks easier to make and assemble. If broken, a part can be replaced . . ." Some entries seemed to get their form by accident; the better ones were the result of defining a need in clear and basic terms and then carefully designing it to answer that need.

Our judges put it this way: "Winners depend on the total effect, brought about by a coordination of a number of skills—not just engineering, not just production, or marketing."

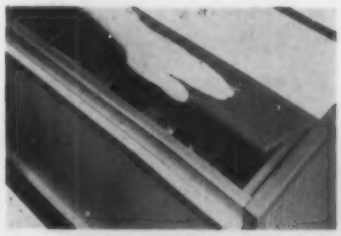
Next Year

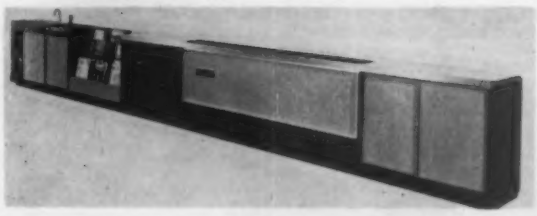
The judges spent a grueling day. You can't study 96 file folders of pictures and product descriptions for five or six hours without feeling the strain. Yet their last comments were a plea for more. The turnout was amazing, considering the short time between announcement of the award program and closing date. But many fine products had not been entered.

This is sure, next year there will be more. ■

annual design awards

UNIT VENTILATOR FOR SCHOOLROOMS





. . . is latest of a type of equipment that heats or cools 6 out of 10 of the classrooms in America. Positioned on window wall of a classroom, the unit adds outside air to recirculated air, which is filtered, heated or cooled, and forced by multiple fans in a prescribed pattern throughout the room.

The unit was designed to be silent, prank-proof, low enough to permit entry of desirable window light and shallow enough to avoid wasting limited classroom space. The ventilator can be augmented by utility cabinets, which match height and depth of units. Recommendations of school-planning consultants led to development of such auxiliary units as a sink-and-bubbler cabinet, magazine rack, movable cabinet on casters and tote-tray cabinet.

The design consultants developed a system that offers color choice without affecting production color. The main body of the unit is manufactured in a charcoal finish; color choices are confined to panels, sliding doors and shelves. This simplifies manufacturing, finishing and inventory.

Herman Nelson Div.
AMERICAN AIR FILTER CO INC
Louisville, Ky

For this product-development program, these **MASTER DESIGN Certificate winners:**

C. S. Stock, manager, School Air Systems Div
John Kline, technical director, School Air Systems Div
R. Nelson, director, American Air Filter Co
A. Hubbard, chief engineer, Herman Nelson Div
F. Baker, chief product engineer, Herman Nelson Div
R. Smith, project engineer, Herman Nelson Div
H. Wright, architectural consultant
J. Stevens Stock, motivation research
D. Dailey, industrial design consultant

DATA TAPE RECORDER

. . . was produced by an accelerated program that sidestepped normal product-development procedures and cut development time in half. A completely separate organizational project was created.

Groups of hand-picked engineering, industrial design, tooling, marketing, manufacturing, quality control, and purchasing personnel—headed by a single project manager—were housed in a special building so that organizational separation would not hamper the free exchange of ideas and talents. An extensive field survey indicated general design concepts and space and package configurations preferred by consumers.

The cabinet was designed so that its features could be adapted to other products. The design proposed consists of extruded corner rails attached to a casting at both top and bottom. This provides a strong, rigid framework to which all components can be mounted.

The field survey also showed a need for control panels that clearly indicate what they control. This called for graphic indication and simplified presentation. To accomplish this, bold symbols, bright colors and strong color contrasts were used, so that, even with peripheral vision, positive identification is assured.

AMPEX CORP
Redwood City, Calif

MASTER DESIGN Certificate winners:

J. J. Jipp, manager, Ampex Data Products Company & vice-president, Ampex Corp
F. T. Walsh, manager, industrial design, Ampex Data Products Co
F. Arden Farey, industrial designer, Ampex Data Products Co

CLINICAL ANALYTICAL SYSTEM

. . . makes possible routine chemical analysis of very small samples. Initially, sales were to the clinical market—laboratories that analyze blood, urine and other medical samples. Now use of the system has been broadened to take in industrial and other laboratories that perform chemical analysis.

It is sometimes dangerous—or even impossible—to take the necessary amount of blood to do an analysis in the traditional way. Before this new system was developed, the doctor had to decide whether to endanger the patient by withdrawing a large amount of blood, or to proceed without all the diagnostic information he wanted.

Now, however, the required tests can be made on a drop or two of blood, easily obtained by a simple finger or heel puncture. This system has found wide acceptance by pediatricians and clinical laboratory chemists.

BECKMAN INSTRUMENTS INC
Palo Alto, Calif

MASTER DESIGN Certificate Winners:

M. Best, industrial designer
E. M. Whitley, manager of engineering
F. I. Fuller, project engineer
F. G. Williams Jr, research engineer
M. C. Sanz, director, Central Laboratory, University Hospital, Geneva, Switz.

VISIBLE RECORD COMPUTER

. . . was developed to take advantage of the new magnetizable ink to automate handling of checks—the biggest paperwork job in banking.

It is the first computer designed to read numbers and symbols directly from visible checks and deposit slips, and post entries directly on customers' ledgers. This eliminates need for punched cards or magnetic tape in bank automation, and permits continued use of visible checks and ledgers.

The VRC reads by recognition of magnetizable-ink characters. The "Common Machine Language" adopted by the American Banking Assoc is used. This language consists of specially designed numbers and characters imprinted in magnetizable ink on the face of checks and on the backs of ledgers.

Four individual machines are linked in this compact system, which requires only one attendant. (1) Checks and deposit slips are read and sorted in the Sorter-Reader, which handles up to 1560 documents per minute. (2) the computer unit processes this information. (3) Record Processor posts and proves the computer's calculations on ledger and statement forms; computes and prints customer's balance. (4) Entire system is controlled from the console.

Some of the more difficult problems successfully solved: high-speed sorting of checks in Sorter-Reader; program units permitting ready interchange in console; loading and selecting of visible ledgers in the Record Processor.

BURROUGHS CORP
Detroit

MASTER DESIGN Certificate Winners:

J. H. Howard, manager, Paoli Lab, Burroughs Research Center
J. M. Sheaffer Jr, project engineer for Sorter-Reader
W. Hanstein, systems engineer for Sorter-Reader; project engineer for Computer & Control
T. A. Dawes, logic engineer for Sorter-Reader, Computer & Control
F. W. Kerfort, project engineer for Record Processor & Console—Engineering Development
N. Sander, supervisor, Industrial Design, Paoli Lab
K. A. Hopkins, associate, L H Wilson Associates, Consultant Designers—Industrial Design & Human Engineering

AUTOMATIC 35MM CAMERA

. . was produced to fill growing need to take guesswork out of amateur color photography. In 1953, an estimated 315 million color stills were made; by 1958, the figure had climbed to 750 million.

This growth was even more pronounced in the 35mm field. Engineering attention therefore was concentrated on the need for an automatic 35mm camera that would provide the best possible pictures in color for the average person.

The available power for controlling the diaphragm was computed to be about 1-billionth horsepower. This could be produced by a photoelectric cell and a miniature precision galvanometer. Best approach seemed to be one in which the galvanometer is used only to measure, not to do work. The galvanometer needle is trapped as the shutter release is pressed to make the exposure. A cam is coupled to the diaphragm to insure that the proper aperture is established at the instant the picture is taken.

As parts were designed, they were studied by the production engineers. In some cases, new production techniques were needed to produce details of the camera.

EASTMAN KODAK CO
Rochester, NY

MASTER DESIGN Certificate Winners:

H. H. Waggershauser, vice-president, Eastman Kodak Co; general manager, Apparatus & Optical Div
A. E. Schubert, manager, Development & Engineering, Apparatus & Optical Div
D. C. Harvey, assistant manager, Development & Engineering, Apparatus & Optical Div

D. L. Wood, assistant to manager, Development & Engineering
J. L. Quigley, assistant superintendent, Development & Engineering
F. E. Altman, assistant director, Optical Design
J. J. Bundschuh, project development engineer
L. J. Craig, senior supervising development engineer
A. H. Crapsey Jr, senior project industrial designer
H. Nerwin, senior supervising development engineer
C. F. Smith, senior supervising development engineer
R. B. Houck, project development engineer
R. E. Guenther, development engineer
W. T. Hochreiter, product designer
R. G. Elton, senior product designer
R. R. Harold Jr, senior product designer
N. M. Pituley, assistant lens designer
C. J. Meloch, assistant lens designer

HIGH-ENERGY-RATE FORMING MACHINE

. . . is a totally new concept in machine tools. The energy of a piston, driven by gas at 2000 psi, is applied during short cycle time of 0.001 sec. This high-impact energy permits forming unusual shapes and exotic materials to close tolerances. Process can be applied to extruding, forging, sheet forming and compaction.

Industrial design started early enough in the over-all development program to have a very strong influence. These efforts extended not only to packaging, but also involved many of the mechanical parts.

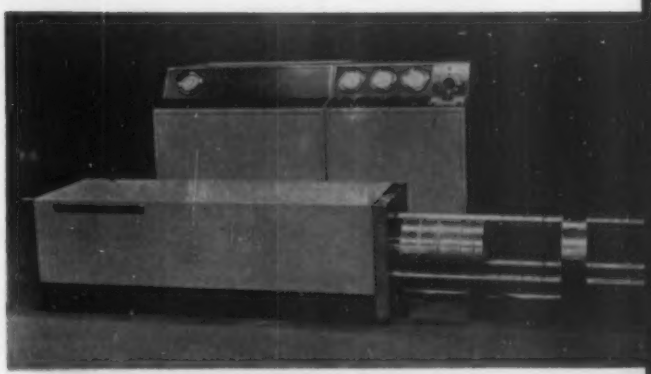
The system has three basic components. The first, the machine proper, required thorough design from the inside out, and development of a sheetmetal shroud of proper proportions. Clean lines and masses reflect quality and function of the mechanism. Human-engineering principles were applied to the maximum. The design philosophy of expressing a new, advanced concept, plus the down-to-earth solidity and mechanical character of this new product was carefully followed.

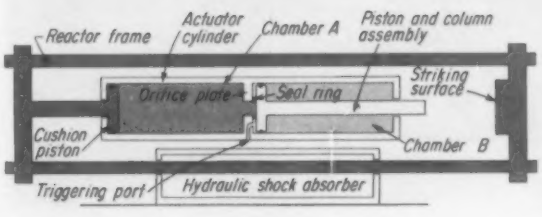
Second part of the system is a control console that represents a design breakthrough in this type of product. The third component is a package for the power supply. This incorporates good human-engineering practice and derives its basic design theme from the control console.

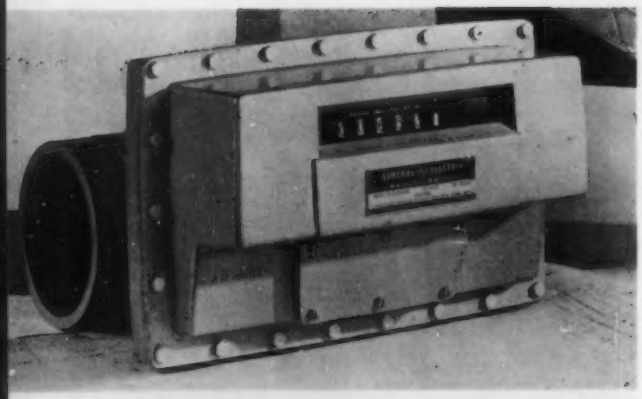
CONVAIR, DIV GENERAL DYNAMICS CORP
San Diego, Calif

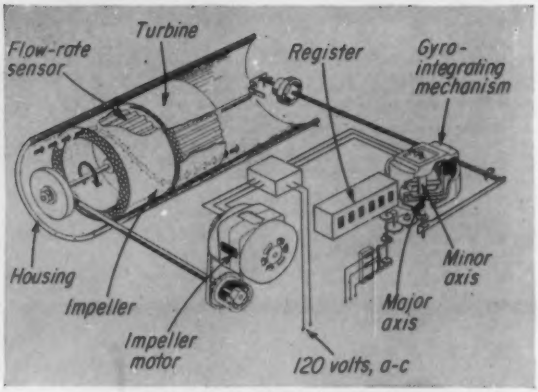
MASTER DESIGN Certificate Winners:

J. Ottestad, project engineer, inventor
R. Monsees, program director
C. Zierhut, industrial designer
M. Shimano, industrial designer









INDUSTRIAL MASS FLOWMETER

. . . was answer to a need for a better method of metering natural gas. To be practical, the meter had to eliminate the need for: volumetric measurements, with the associated problems inherent in orifice metering; collection of chart records; pressure/temperature measurements; record integration.

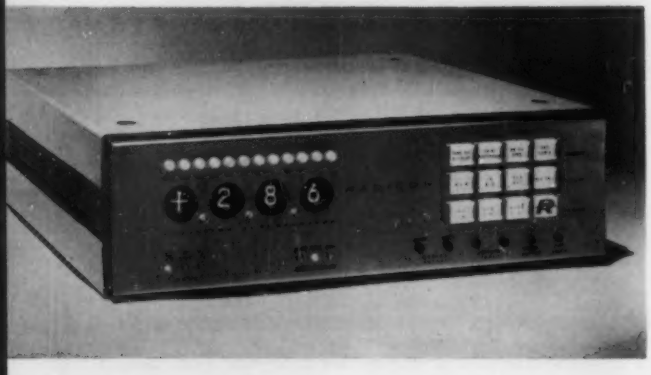
One of the first problems was that of continuous integration. Conventional approach is to generate an electric signal proportional to flow rate, then feed this into servo-type electromechanical mechanism that positions a ball-and-disk integrator. But this is expensive and necessitates electronics that should be avoided if possible.

Instead, the idea was conceived of using a two-axis gyroscope as an integrator. Any unbalanced force applied about the minor axis of a spinning gyro produces a precession or rotation about the major axis. The angular velocity of this precession is directly proportional to the force applied to the minor axis. Since the flowmeter output is in the form of a torque directly proportional to flow rate, this torque is applied to a gyro and integrated by totalizing revolutions or angular displacement about the major axis.

INSTRUMENT DEPARTMENT, GENERAL ELECTRIC CO
Kansas City, Mo
BLACK, SIVALLS & BRYSON INC
Kansas City, Mo

MASTER DESIGN Certificate winners:

GENERAL ELECTRIC
H. E. Trekell, consulting engineer
H. T. Wrobel, manager, Flowmeter engineering
D. S. Cleveland, development engineer
W. H. Burnham, design engineer
J. R. MacIntyre, development engineer
J. B. Stewart, application engineer
E. F. Hanlon, manager, Industrial Instrumentation Drafting
W. W. Hiland, manager, Manufacturing Engineering
L. T. Akeley, development engineer
J. W. Pendleton, specialist, Methods & Planning
H. S. Day, manager, Instrumentation Equipment Sales
E. E. Parker, general manager, Instrument Dept
R. E. Reichelt, sales engineer
BLACK, SIVALLS & BRYSON INC
W. Scheirman, supervisor, Process Engineering
C. Haisell, supervisor, Development Engineering
E. Mitchell, product planner
A. J. Goodwin, engineer
E. J. Bonner, development engineer
L. Holder, laboratory technician
L. L. Laurence, vice-president, Engineering
Dr E. E. Young, product planning coordinator
M. S. Worley, manager, Research & Development



DATA-ACQUISITION EQUIPMENT

. . . consists of a high-frequency, sequential-sampling, electronic switch for time-multiplexing many channels of analog data, serially, onto a single output channel in accordance with programs of channel selection and sampling rates. A reversible electronic coder then converts the analog data into any of several forms of digital codes for storage and computer processing.

A new approach was tried for the development of this equipment in which the importance of mechanical design, human factors and appearance design equalled that of circuit design. Such an approach produced a more integrated product having increased consideration for operator use, over-all appearance, and manufacturing cost.

Initial work of the design group was critically reviewed and the conclusion reached that developments at that point

HEAVY-DUTY, HIGH-SPEED ROUTER

. . . This machine was redesigned with a specific aim in mind: The visual values of this product have to attract attention, build desire, and lead to buying action.

Increased sales, without cost increase, was the ultimate goal. This was a challenge to the design firm's philosophy of "value analysis." Every phase of manufacturing had to be considered. This suggested many changes from the old machine-manufacturing methods. The designers determined where most of manufacturing costs were, and designed these factors out of the new machine as much as possible.

Functional features engineered into the router include: vacuum pulley; 2-speed motor control; high-speed, interchangeable spindle assembly; automatic spindle-brake actuation with pneumatic foot control for lowering and raising the router head. Vertical feed-stop adjustment was relocated and changed for operator convenience. The depth stop is easily set to stop feed automatically at any level in 0 to 3¼-in. range. Adjustable table allows faster and easier set-up than the old machine.

The designers also prepared full-scale contour-detail drawings of the body casting, covers, hand wheel, knobs, handles and the front fiberglass cover. Further advantages of this design program were the development of a new and modern trademark and a newly styled name logotype. Final art for all nameplates was also prepared by the design firm.

ONSRUD MACHINE WORKS INC
Niles, Ill

MASTER DESIGN Certificate winners:

C. R. Onsrud, vice-president
R. M. Miller, vice-president
J. Karlovitz, engineer
R. L. Deschamps, Designer, Palma-Knapp Assoc.
J. Palma Jr. Designer
J. G. Knapp, Engineer

BEFORE

AFTER

were not radical enough, and were still dominated by too much electrical-engineering thinking.

The mechanical engineers developed a new printed-wiring-card format, which more efficiently accommodated the requirements of the equipment and allowed for higher component densities within a greatly simplified structure.

Here's what the final development did:

1. Eliminated mounting hardware on front panel.
2. Eliminated all superficial decorative trim.
3. Integrated the rear connection panels into the total design of the units.
4. Simplified panel nomenclature and placement.
5. Established typographical style and use recommendations for product name and corporation signature.
6. Simplified the exterior case.

RADIATION INC. Melbourne, Fla

MASTER DESIGN Certificate winners:

L. W. Gardenhire, director, Astrionics Division
R. E. Marquand, project engineer
W. Corry, mechanical engineer
R. Spilman, consultant industrial designer
C. F. Stephenson, project industrial designer

RADAR UNIT AND DIRECTION FINDER

. . . were developed as part of a program to produce a series of lightweight instruments for small boats. Along with the industrial design efforts, engineering produced basic sketches and layouts. This allowed much of the engineering work to be well advanced by the time the final appearance models were presented. Interior-component arrangement, chassis design, etc., were ready by the time the appearance models, layouts and sketches were completed.

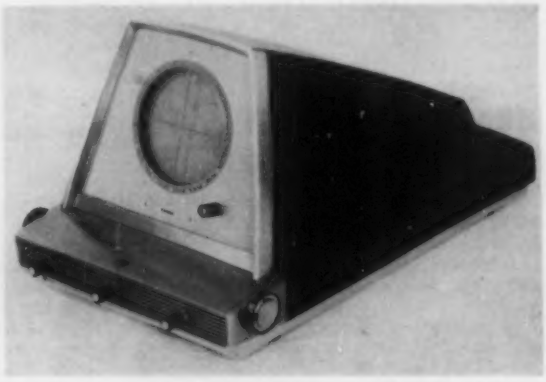
The compact packaging of the components for these units presented a challenge to the engineering group, but it was able to design an end product identical to the model.

A notable feature of these companion units is the design of a common die-cast front housing. In addition to the obvious advantages, it has allowed the designer to use this element as a part of the corporate identity the producer was attempting to establish.

The top cover of the radio direction finder is of molded fiberglass, with a molded plastic azimuth ring, molded-in degree indications and identifications. Base panel is made of brake-formed textured aluminum. The assembly provides easy access for servicing.

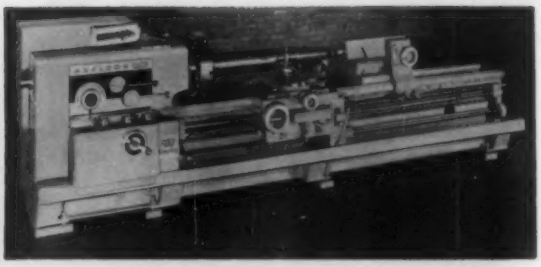
Different top cover on the radar unit was fabricated from metal and coated with a vinyl spray. Standardized control knobs were designed and will be used with the various products throughout this venture.

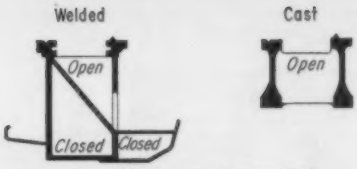
Sperry Piedmont Commercial Products Div
SPERRY RAND CORP
Charlottesville, Va



MASTER DESIGN Certificate winners:

C. W. Sundberg, president, Sundberg-Ferar Industrial Designers
M. Ferar, vice-president, Sundberg-Ferar Industrial Designers
R. Figgins, executive director of design, Sundberg-Ferar Industrial Designers
W. Roberts, mgr, Commercial Products Div, Sperry Piedmont Co
W. Otis, Sperry Engineering
L. Purnell, Sperry Engineering
D. Klein, Sperry Engineering





Comparison of cast-iron and new welded-steel beds

ALL-WELDED ENGINE LATHE

. . . resulted from a long, critical look at lathe design. An intensive survey produced some very difficult objectives for R & D engineers.

Universal acceptance of carbide and ceramic cutting tools by lathe users demanded higher cutting speeds and greater rigidity to obtain maximum utilization. These features were incorporated in the new design, yet the new lathe is competitively priced.

Its design was based on the necessity to incorporate the following major objectives: increased rigidity, higher horsepower, greater range of spindle speeds, increased range of cutting feeds, choice of manual or preselected power shifting, provision for numerical control, plus modern styling and ease of operator control. Also, minor design refinements were made and several new accessories included.

To meet objectives, a major departure from conventional lathe design was necessary. The following features resulted:

1. All basic driving mechanisms were incorporated in a single rigid structure.
2. Headstock was extended to the floor and flange-mounted to the bed.
3. Bed was extended to the floor—to obtain max section depth—rather than leaving it perched on a pedestal.
4. Interchangeable, modular units were designed, to provide a wide variety of beds with a single headstock.
5. Lathe was designed for high production levels using ceramic and other types of modern tooling.

Clearing Div, US INDUSTRIES INC
Chicago

MASTER DESIGN Certificate winners:

P. N. Stanton, manager, Machine Tool Div
G. M. Sommer, director, R & D, vice-president
V. Mankowsky, assistant director, R & D
J. K. Liu, senior project engineer
J. M. Little, industrial designer, J M Little Assoc
K. Peglow, plant superintendent

Want precision plastic parts like these? In quantities that don't justify the high tooling cost of injection molding? Build or buy a centrifuge, experiment a bit—and you're ready to start producing . . .

EPOXY PARTS CAST BY CENTRIFUGAL FORCE

RAYMOND BUENGER, *supervisor, engineering and model shop*
Scientific and Process Instruments Div, Beckman Instruments Inc

The casting of plastic prototypes is one unusual engineering use for epoxy resins. Another is production casting in very small quantities. Both lead logically to application on a still larger scale—the centrifugal casting of epoxy parts in epoxy molds. This method allows economical production of up to about 500 parts, by exploiting the following advantages:

- From 2 to 12 parts can be cast simultaneously, without special equipment.
- A simple centrifuge can be purchased or built for under $300.
- Molds are inexpensive because they are made with castable epoxy tooling resins.
- Epoxy molds can be made quickly—in only a few days compared to the 2 to 6 months needed for injection- or compression-molding dies.
- Parts are finished as-cast. Only gates and minor flash have to be removed.
- Finished tolerances are close, ±0.005 in. is easily held.

Other natural advantages of castable epoxies, obtainable in stationary, single-cavity casting, are available in centrifugal casting too. The major ones are these:

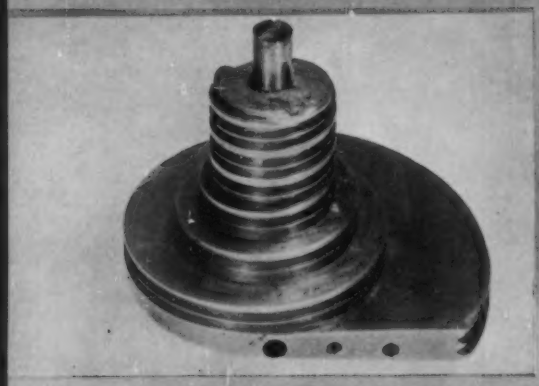
- Mechanical properties and corrosion resistance of epoxies are superior to those of other room-temperature curing resins such as phenolics and polyesters.
- Rigid or flexible epoxies are available, and readily pigmented in any color.
- Epoxy systems—resin, hardener, fillers, and mold-release agents—are well established, and straightforward to handle with a little practice.
- Shrinkage during cure is low—at least for smaller parts—thus metal parts can be embedded without cracking of the epoxy or damage to the insert.

HOW TO GET STARTED

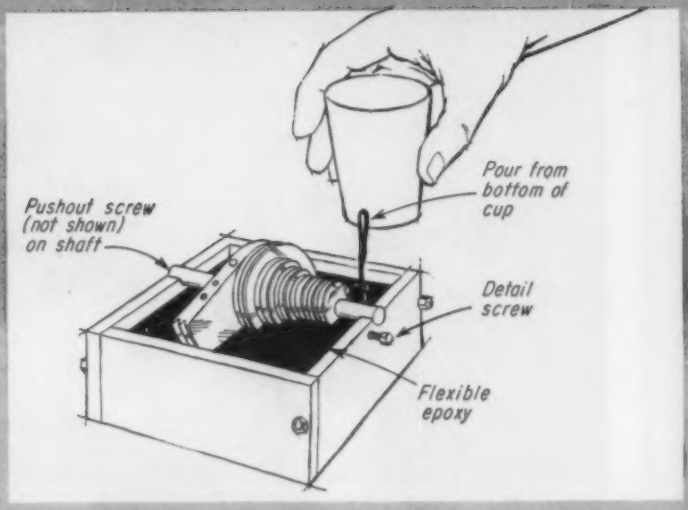
Learning how to handle epoxy resin systems is the first step, and the simplest way to do this is to experiment with a simple shape in a single-cavity, stationary mold.

text continued on page 48

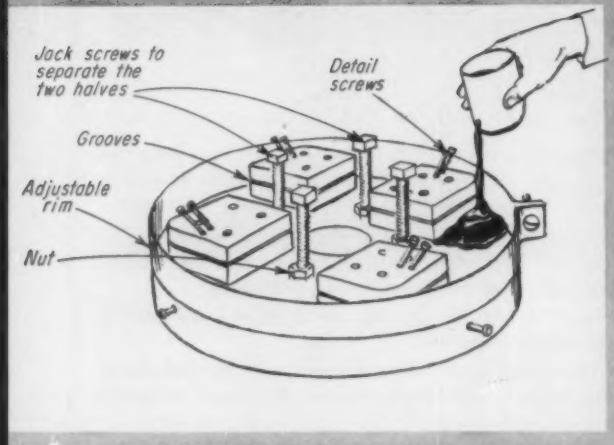
8 BASIC STEPS MAKE COMPLEX CAMS for Spectrophotometer



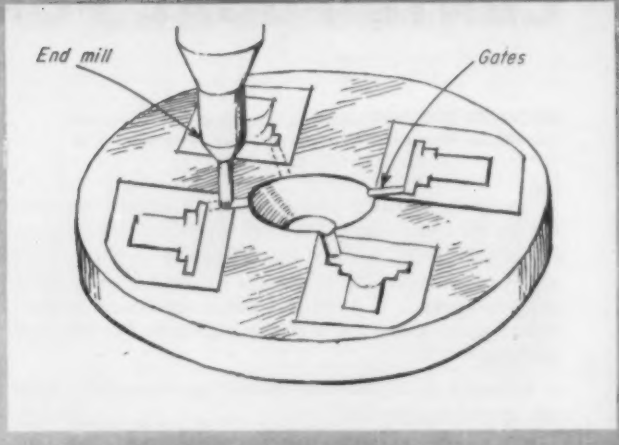
1 MAKE THE MASTER by machining from either metal or acrylic resin to precise dimensions required. Here, metal windup cam had already been made to prove design of a new infrared spectrophotometer—thus providing an accurate master. With tolerances on critical dimensions of ±0.005 in., this complex shape is a good example of hard-to-get parts that can be centrifugally cast. Number of cams required was 500, an ideal quantity for economical production by this process. A simpler part should be selected by the beginner for the first try.



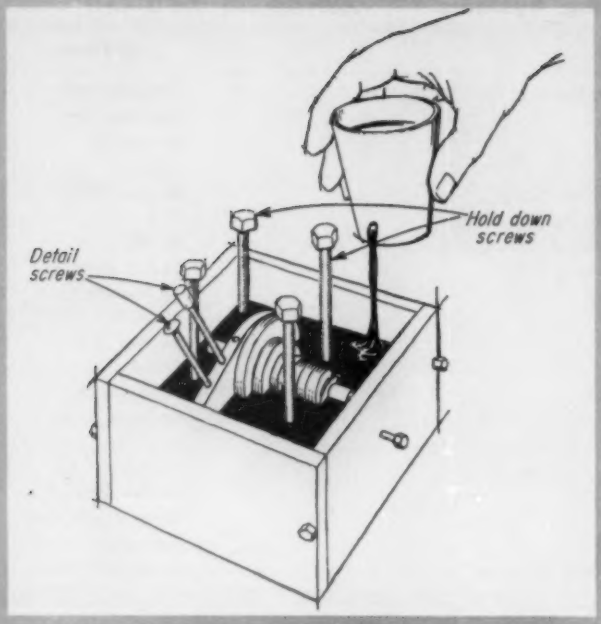
2 POUR BOTTOM HALF of the first split mold, using a fairly flexible epoxy like Rezolin L-930 (see Table II) to assure easy removal of the master. Form is made of aluminum plate, notched to carry the shaft supporting the master pattern. First half is hardest to make—poured epoxy has to form the mold from underside of the master. Best technique: pour slowly to avoid air entrapment. Detail screw at right, passing through form into threaded hole in master, is backed out of cured mold when master is removed, and reinserted to act as pattern for threaded hole in cast part. After master is removed, half-mold is sanded to a smooth flat surface. Push-out screws assist removal of master.



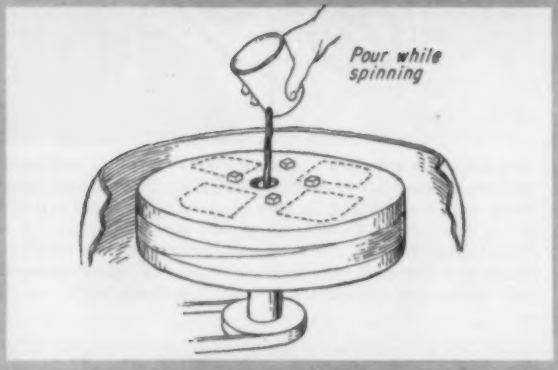
5 EMBED THE TOP HALVES after turning over the cured composite mold made in step 4 and assembling the individual top halves to their mating molds with countersunk cap screws. Top halves should be also grooved to prevent loosening. Same sheetmetal rim in step 4 can be used here. Dowel pins are usually needed; but here, shaft in master pattern serves as positioner. Jack screws with nuts, for opening the finished composite mold after a casting cycle, can now be embedded as needed. All surfaces, except those of mold halves being embedded, should be waxed before pouring.



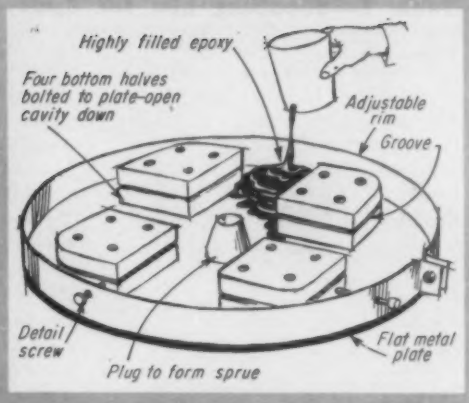
6 MILL SEMICIRCULAR GATES in the mold from the sprue to the cavities, maintaining symmetry to maintain balance. Risers in centrifugal castings are unnecessary—pressure forces casting resin into the cavities. If proper forethought is given to mold construction, all hold-down screws, jack screws, detail screws, sprues, bosses, etc, can be cast in the composite mold and only the gates need be machined. Note that gates are cut only in the half of the mold containing the sprue; viscosity of epoxy casting resins are very low and not much area is needed for flow, especially since the resin is under pressure.



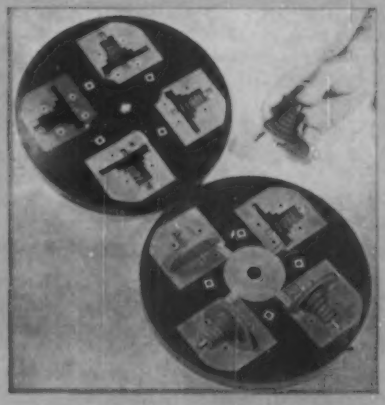
3 POUR TOP HALF of the first split mold, with master in place in previously cast bottom half. New and higher forms must be made, and hold-down screws must be tapped through bottom half before pouring—so two halves can be tightly closed when the part is cast. (Another closure technique: embed nuts in bottom halves, bushings in top halves to pass hold-down screws.) Additional detail screws are included as needed to provide patterns for threaded holes in cast part. A heavy wax coating is necessary on all surfaces, epoxy bottom half included, for easy release. Remove screws and master; repeat steps 2 and 3 to get as many sets as can be accommodated in centrifuge diameter—in this case, four sets.



7 CENTRIFUGALLY CAST THE PARTS after cleaning the composite mold, waxing it with a hard paste wax, and coating it with a liquid mold-release. In this case, the four mounting shafts, detail screws, and hold-down screws must be coated and adjusted. With empty mold spinning at about 400 rpm (for cavities 4 to 6 in. from center), pour epoxy into the sprue as fast as it deposits into the cavities. Spin at this speed for about ½ hr to be sure all bubbles are removed and all detail filled. Do not spin too fast at this time or resin and fill will separate. Leave mold standing until resin becomes rubbery (depends on the resin, cavity size, and room temperature). Now spin at 1500 rpm to form completely air-free part without shrink marks. Time at this speed must be established by trial; when mold is removed, epoxy should hold its form. Cure overnight in closed mold.



4 EMBED THE BOTTOM HALVES in a rigid epoxy matrix such as Rezolin Epolite 30, a highly filled black casting resin with low exotherm and low shrinkage. This is done by fastening the four bottom halves, grooved along the edges to prevent loosening, to a flat metal plate having a sheetmetal rim around the periphery. Bottom halves should be open-cavity down and positioned symmetrically with the center. Place a plug, tapered to 45°, in the center to form the sprue. Previously positioned detail screws should be inserted and all surfaces waxed before embedding. If too much internal heat is generated in embedding matrix, causing shrinkage cracks, cast a new matrix with more filler. Epolite 30 used with L-932B hardener will cast to 2-in. thickness without shrinkage cracking.



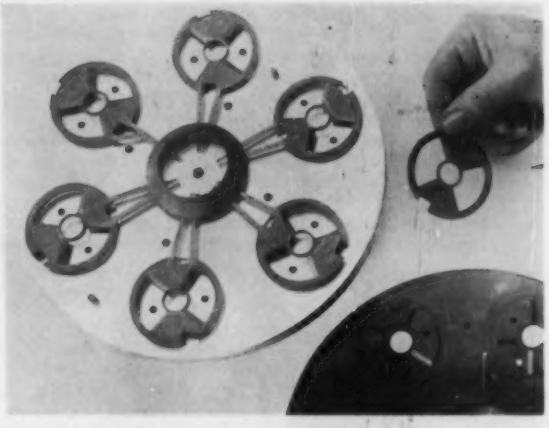
8 OPEN THE MOLD AND REMOVE THE CAST PARTS. Detail screws must be backed out first, the mold opened with jack screws, and the parts loosened with push-out screws. If the mold is properly constructed, flash will be very thin—from 0.001 to 0.002 in.—and can be easily removed. The only other handwork necessary is removal of the gate, which can be done with a hand file. After parts are removed from mold, keep mold halves together to avoid damage to parting-line edges and other critical details.

Table I—Shopping List for Epoxy-casting Systems

Tradename	Manufacturer	Address
———	Alayite Plastics & Chemical Co	Newhall, Calif
Airtemp	Aries Laboratories	Stamford, Conn
Helix	Biggs, Carl H Co	Los Angeles
———	Bisonite Co	Buffalo
Devcon	Chemical Development Corp	Danvers, Mass
Cordopreg	Cordo Molded Products	New York
———	Dennis Chemical Co	St Louis
Stycast	Emerson & Cuming Inc	Canton, Mass
Epocast	Furane Plastics Co	Los Angeles
Hysol	Hysol Corp	Olean, NY
Epi-Rez	Jones & Dabney	Louisville, Ky
———	Kelox Co	Clifton, NJ
———	Kish Industries Inc	Lansing, Mich
———	Lawrence Adhesive & Chemical	Lawrence, Mich
Randac	Mitchell-Rand Insulation Co	New York
Castiplast	National Engineering Products	Washington, DC
RP series	Ren Plastics	Lansing, Mich
Rezolin	Rezolin Inc	Santa Monica, Calif
Epoxical	US Gypsum Co	Chicago
———	Western Tool & Mfg Co	Springfield, Ohio

Table II—Properties of Two Casting Resins

Properties	Epolite 30 (with L-932B hardener)	Resin A (with L-930 hardener)
Color	Black	Grey
Castable Thickness, in.	2 to 6	⅜ to ¾
Shrinkage, mils/in. @ 77 F	0.5	0.1 to 0.5
Hardness (7-day cure), Shore @ 77 F	82–85	85
Specific Gravity @ 77 F	2.02	1.33
Density, lb/cu in.	.072	.048
Flexural Strength, psi	7,400	11,000
Compressive Strength, psi	12,000	12,000
Tensile Strength, psi	2,500	4,000
Thermal expansion coeff, in./in. per °F x 10^{-6}	23	30



SIX-CAVITY MOLD for a mirror mask used in ultraviolet spectrophotometer is made half aluminum and half epoxy. Note that most detail in this case is in the epoxy side to avoid machining. Rosette of as-cast parts was replaced for this photo. Note dowel pins for alignment, and two hold-down and two jack screws for each cavity. Gate for upper left cavity was redesigned to miss hold-down bolts.

Casting epoxies are widely available (see tabulation of sources in Table I, above). These manufacturers supply complete systems, with a remarkable number of variants, and will supply literature on proper use of their products upon request. In your first attempts at casting, try two or three resin systems and pick the one that seems easiest to handle.

Once confidence in casting epoxies has been achieved, centrifugal casting is an easy next step. The 8-step procedure shown in detail, pages 46 and 47, was for an actual production part—a windup cam—for the Beckman IR-5 Infrared Spectrophotometer. Careful planning is the key to success, as study of this example will show.

The epoxies chosen for mold and cast part in this application were, respectively, Resin "A" and Epolite 30—both produced by Rezolin Inc. Other systems would be satisfactory too. Epolite 30 is a black, highly filled epoxy that gives rigid castings when used with L-932B hardener. This combination can be cast in thicknesses up to 2 in. without excessive internal heating or shrinkage—even when the mold material is a poor heat conductor. Resin "A" uses an aluminum-filled hardener L-930, and its hardness can be controlled by adding Flexicizer—also a Rezolin product. This feature makes it a good mold material, since critical detail areas will flex slightly instead of chipping when the casting is pushed out. Properties of both these resins are included in Table II.

DESIGNING THE MOLD

Regardless of the epoxy combination you choose, there are a number of simple rules for designing multiple-cavity molds. These rules will simplify mold construction as well

Table III—Cost Comparison

(Cost figures in $)

Part	Molding (1) Injection (2) Compression				Machining			Centrifugal Casting			
	Estimated				Estimated			Actual			
	Number of Cavities	Cost of Tooling	Cost of 1 Part	Cost of 500	Cost of Tooling, Drill Jigs, etc.	Cost of 1 Part	Cost of 500	Number of Cavities	Cost of Tooling	Cost of 1 Part	Cost of 500
Window holder	1 (2)	3200	0.50	3450	300	20	10,300	8	400	3.00	1900
Mirror mask	1 (1)	1500	1.00	2000	420	12	6,420	6	320	2.10	1370
Windup cam	1 (2)	3200	1.27	3835	...	..	.....	4	580	5.00	3080

as cut time expended and materials wasted to a minimum. Parts centrifugally cast in such molds will have the surface of molded parts, and consistent tolerances.

Determine the number of cavities by the size, complexity and quantity requirements of the part—and by max diameter of the centrifuge. Allow room for sprue, gates, hold-down screws, jack screws, detail screws, and mounting bolts for the centrifuge.

Orient the cavities around the sprue so that air will not become trapped as the resin flows in. Best method is to keep straight sides of the cavity at 45° to the gate line. The rectangular window cell-holders shown at right in photo on p 45 illustrate this point: Note the flow lines, showing that resin flowed freely to all eight cavities.

Cast the individual cavities separately (see example) and embed them in a common matrix. Thus, if one cavity is damaged it can be replaced.

Balance the mold by keeping all cavities, screws, inserts, etc, equidistant from the center. Irregular cavities and all gates should be arranged symmetrically (see example) for balance. If these precautions are not observed, the rotational speeds needed for casting cannot be reached without damage to mold or centrifuge or both.

Use metal for one side of the composite mold whenever design permits. This applies most often when the cast part has one flat side; then the epoxy side of the mold can give the required detail. The 6-cavity mold pictured on facing page is a good example. One metal side simplifies mounting problems and gives a rigid, flat parting line when the mold is bolted shut.

Keep sprues large (for easy pouring) and the gates small at the point of entry to the cavity (for easy clean-up). The low viscosity of castable epoxies and the pressure generated in spinning the mold make small gates possible.

Design as much detail as possible into the cavities. Epoxy parts, particularly those with fillers, are quite difficult to machine in production quantities.

Add draft to all parts, except when little depth into the mold is required. Minimum draft is 2°, but larger draft angles are desirable to make parts easy to remove and to avoid damage to mold edges.

Always use a mold release agent, since epoxies make excellent adhesives. Most resin-system suppliers have matching release agents and directions for their use. A good base for any such release agent is a polished coating of hard (carnauba-based) paste wax.

COST CONSIDERATIONS

The cost-comparison chart on this page shows the tangible savings possible with centrifugally cast epoxies when correct procedures are followed, and when production quantity is in the right range. Of the three parts included, the windup cam uses the most epoxy. Since epoxies are not cheap (about $1 per lb in gallon lots), this last part shows the least savings over machine-molded plastic. Even though the cost for one cast cam is $5, this represents material and labor—with only $580 tied up in tooling. This means the cam design can be changed easily or production stopped well below 500 units without great sacrifice.

These figures also show what a trap machining can be in moving from prototype into intermediate production. Perhaps the first few models use machined parts. Production goes up slowly, and the temptation is to have the shop continue to machine the needed part—perhaps fitting the work in odd hours. Before you know it, 500 parts have been made and costs are way out of line. Centrifugal casting, then, can serve as the bridge between low and mass production.

EDITOR'S NOTE: Other recent articles covering unusual engineering uses for epoxy casting resins include:

Speed Your New Product with Cast Epoxy Models, Dec 21 '59, p 60—How to convert your new-product ideas quickly and directly into actual parts or assemblies, allowing simultaneous appraisal of many designs.

Epoxy Castings, June '57, p 135—Covers characteristics of casting resins and how epoxies fit in; how to design large castings as low-cost alternatives to metal for low-volume applications.

Three-dimensional Photoelasticity, July '57, p 135—How to use epoxy casting resins as the key to more effective use of a powerful stress-analysis tool.

Selecting the right SOLENOID

Here for the first time is a guide to ac and dc solenoids of both linear and rotary types. Author tells what they do, how they operate, which one is best for what application, and who are the suppliers.

ERMINIO A SCUTARI, *assistant editor*

What Makes It a Solenoid?

Solenoids can be classified by the type of motion they produce—either linear or rotary.

All solenoids, regardless of type, consist of a stator and a rotor. The stator (also called the coil-core) produces an electromagnetic field. The rotor (armature) is pulled toward or into this field with limited displacement, doing mechanical work.

The space between the armature and coil is called the airgap. Total effective airgap includes all openings in the magnetic path.

When you need to convert an electrical signal into force—to move a load over a limited linear or rotary range (stroke)—consider using a solenoid. Although a motor can accomplish the same result, a solenoid is probably your best bet because it usually is less expensive and needs less space, power and maintenance.

The most commonly available linear and rotary solenoids have the following capabilities. Linear solenoids can move forces from one-third of an ounce to 350 pounds and generate strokes from 0.01 to 5 in. Rotary solenoids can move torque loads from ½ in.-oz to about 100 in.-lb and generate rotary strokes from less than 5° to as much as 95°.

AC vs DC

Solenoids are available for operation by either ac or dc power sources, although some dc solenoids can be used on ac as well—with a rectifier. For ac solenoids, pull forces are generally limited to a maximum of 50 lb. The ac types are bulkier, more complex and, generally, slightly noisier than dc solenoids. However, the ac devices respond faster, are more adaptable to long-stroke applications, and in general cost less than their dc counterparts. These features account for the extensive use of ac solenoids in household appliances. Where high reliability and high efficiency are required, and cost is not a limiting factor, dc solenoids usually are preferable.

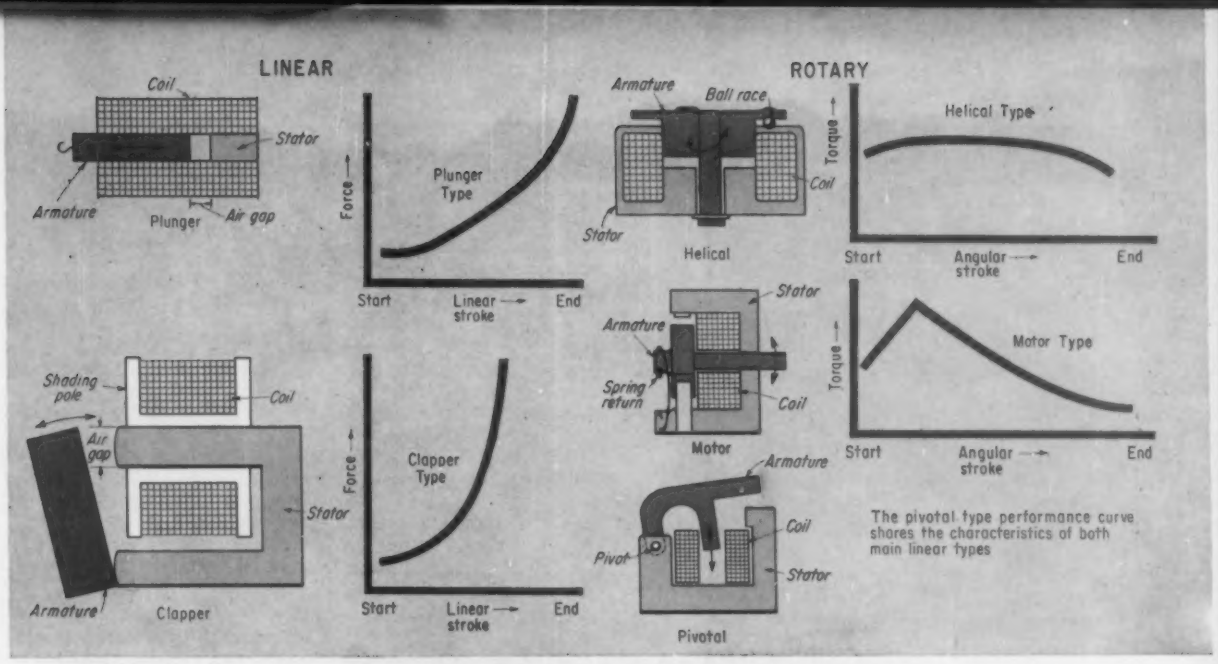
Here are details on the types of solenoids illustrated on next page.

LINEAR TYPES

Linear or straight-pull solenoids can be divided into two main kinds: plunger and clapper.

A plunger solenoid has a cylindrical coil; the armature (plunger) is pulled into coil's center when coil is energized. Pull force increases only half as fast as in the clapper type, and does only half as much work per given stroke. Plunger-type solenoids can handle short- and long-stroke applications, but are usually less efficient than the clapper type because of the open magnetic circuit.

To make sure the plunger can complete its stroke—select the solenoid, spring rate (in spring-loaded applications), and initial load so that the solenoid force is greater than the load throughout the stroke. Greater care and selection is required for an ac solenoid because of the severe hammer-blow problem it presents. Hammer blow (impact of the plunger on the solenoid frame), which represents the difference between available and useful work, reduces the life of the solenoid. To minimize this



EXAMPLES OF BASIC SOLENOID TYPES AND THEIR PERFORMANCE CURVES

impact in ac solenoids, make sure the solenoid force is large enough to ensure a complete stroke, but not so large that available work of the solenoid greatly exceeds useful work done. Particular care should also be taken not to restrict seating of the plunger.

Clapper solenoids take up less space than the plunger type; the armature is pulled against the stator core, rather than into it. Airgap is small and stroke is short, giving a higher force for the same volume and weight.

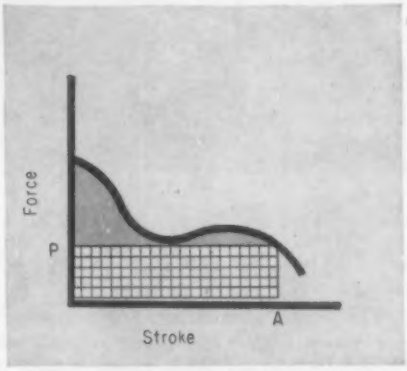
Clapper solenoids are relatively inexpensive, and generally have a hinged armature (the clapper). Their characteristics—low pull-in force, high hold-in force—make them useful for brakes and clutch mechanisms.

ROTARY TYPES

Rotary solenoids produce a rotational stroke. There are three types: helical, motor or true rotary, and pivotal.

Helical solenoids are simply straight-pull solenoids whose armatures are given a helical or twisting motion as they pull into the coil.

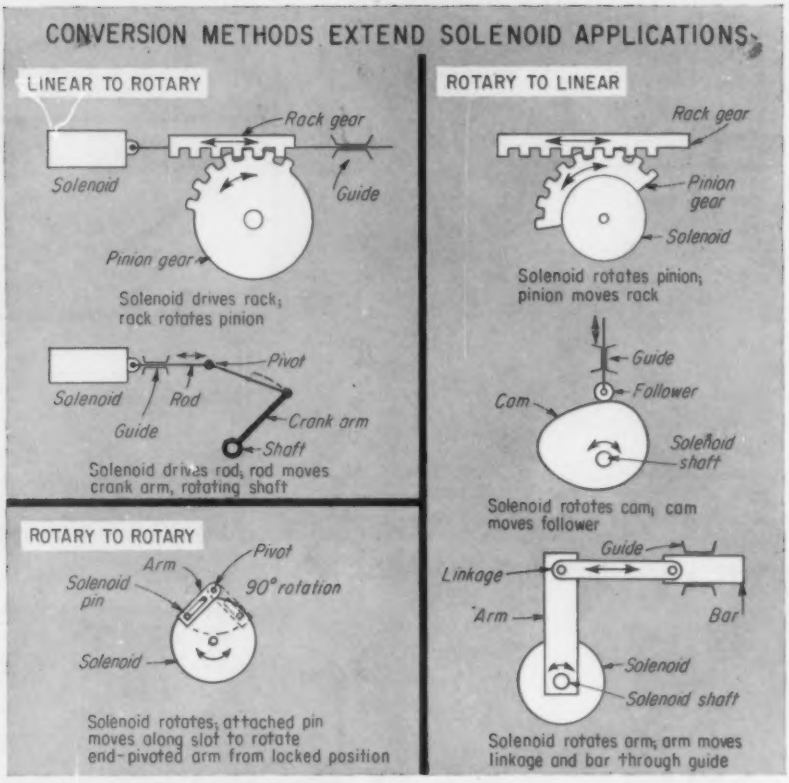
This rotary type, such as made by Ledex, has its armature supported by three precision ballbearings in ball races on top of the coil-core case. When the solenoid is energized, the armature is pulled into the coil and ballbearings move along compound incline of the ball races. Because the armature is supported by ballbearings, it follows the direction of the bearings, which give it a rotary motion. Incline of the ball race is steep at the beginning of the stroke, where airgap is widest and the pull-force weakest. Slope levels off toward end of stroke, where the ballbearings approach deep end of the races, airgap is smallest, and pull-force strongest. This design gives relatively uniform torque throughout the stroke. Variable-torque output is also possible with special ball races.



FORCE-STROKE CURVE for an ac solenoid shows energy dissipated in hammer blow. Rectangular area represents useful work done by solenoid in moving load *P*. Note that stroke starts at point *A*. Shaded area represents difference between available work and useful work; this energy is transferred to the frame in hammer blow.

Helical rotary solenoids can withstand severe linear shock or acceleration because the armature is inherently in dynamic balance. But linear solenoids must be counterbalanced for similar protection.

Motor-type solenoids do not move axially. They depend on an unbalanced (distorted) magnetic field to rotate the armature. It is similar to a stalled motor that rotates 90° or less. The motor-type rotary is suited to low-torque, low-current applications. As produced by Leetronics Inc, this rotary solenoid is essentially a stator and a shaft-mounted rotor. When the coil is energized, the magnetic field causes the rotor to pivot without axial shift. The rotor is spring-returned and has adjustments for selecting torque and angle desired. This type is available with



ADAPTATIONS of basic solenoid designs can broaden range of usefulness. For example, you might need the compactness of a rotary solenoid in a linear application; or the extra force of a linear solenoid for a rotary application. Ideas here were supplied by Cliff Strain of Ledex Inc.

either high or low starting torque, and low or high end torque.

The pivotal solenoid is actually a hybrid of the linear and rotary types. Its armature is a combination of a plunger and clapper, yet it produces rotary motion. Therefore it is classified here as a rotary solenoid. Mechanical output is taken at the pivot. The full angle of rotation is limited, but the design is low-cost. It is available for dc and ac sources, with laminated-core construction for nonrectified ac operation.

WHEN SELECTING A SOLENOID

These are the four steps to be followed when making your decision:

- Determine load requirements.
- Match load requirements to general solenoid type.
- Investigate available sources.
- Modify needs to available component.

Finding Load Requirements

See "Checklist for Preparing Load Data" (facing page) to evaluate the actual load to be handled by the solenoid. The data will aid the supplier in making recommendations.

Power Supply. Specify all power types available. A dc solenoid is frequently the preferred choice. However, recent indications are that the ac type is becoming preferable, particularly in industrial applications. If only ac power is available, first consider dc solenoids used with a rectifier. If a dc solenoid doesn't meet your requirements, consider the characteristics of the ac type and the problems they present. A solenoid, whether ac or dc, should be selected on the basis of "recommended load," usually 85% of rated voltage applied to the coil. Because input-voltage variations have a large effect on solenoid performance, it is good practice to select solenoids for performance at minimum expected voltage.

Duty Cycle. State whether duty cycle will be continuous or intermittent. If intermittent, give the duration of ON and OFF time, and frequency of operation. It is often helpful to express duty cycle in percent of ON time for a cycle.

Load Characteristics. Prepare a force- or torque-stroke curve of the load. Force produced by the solenoid at any part of the stroke should, in general, always be greater than the load requires. The shortest possible stroke gives the highest efficiency. Shorter strokes require less current, and have faster operating rates, more force, and less destructive energy. A shorter stroke solenoid usually has longer life.

Mounting. Some applications require the solenoid to be isolated for vibration and shock. Others require a heat sink for dissipating electrical energy applied to solenoid. Make sure that the armature rides freely during the stroke. In ac solenoids particular care must be taken to allow the armature to seat firmly at end of the stroke. It is good practice to discuss mounting methods with the manufacturer.

guide to solenoid suppliers

Manufacturer	Address	LINEAR			ROTARY	
		Plunger	Clapper	Helical	Motor Type	Pivotal
Artisan Electronics Corp	Morristown, NJ	✓	✓			
Automatic Switch Co	Florham Park, NJ	✓				
B H Hadley Inc	Los Angeles	✓				
Cannon Electric Co	Los Angeles	✓				
Controls Company of America	Schiller Park, Ill.	✓				
Curtiss-Wright Corp	E Paterson, NJ				✓	
Detroit Coil Co	Ferndale, Mich	✓				
General Electric Co	Bloomington, Ill	✓				
Guardian Electric Mfg Co	Chicago	✓	✓		✓	
Ledex Inc	Dayton, Ohio			✓		
Leetronics Inc	Brooklyn		✓		✓	
Modelectric Products Corp	Asbury Park, NJ	✓				
National Acme Co	Cleveland	✓				
Pacsol Div, Illinois Tool Works	Hawthorne, Calif			✓		
PSP Engineering Co	Maywood, Calif	✓		✓	✓	
Roto Manufacturing Co	Xenia, Ohio					✓
Trombetta Solenoid Corp	Milwaukee	✓				

CHECKLIST FOR PREPARING LOAD DATA

A. Power Supply
- a. Ac, dc, or both
- b. Operating voltage (max, min, nominal) and 85% voltage (recommended load for industrial applications)
- c. Frequency (if current is ac)

B. Duty Cycle
- a. Continuous
- b. Intermittent
  1. maximum ON time
  2. minimum OFF time
  3. frequency of operation (operations/min.)

C. Load Characteristics (plot of stroke vs torque or force)
- a. Torque or force
  1. starting torque or force
  2. maximum torque or force
  3. end torque or force
- b. Stroke
  1. length or angle of stroke
  2. shortest stroke

D. Direction of motion (linear, rotary)
- a. Push—linear
- b. Pull—linear
- c. Turn direction (cw or ccw)—rotary

E. Mounting (position of plunger)
- a. Vertical (with or against gravity)
- b. Horizontal

F. Ventilation and Cooling
- a. Ambient temperature range
- b. Cooling means available

G. Environmental Conditions
- a. Temperature, humidity, and pressure
- b. Vibration
- c. Shock
- d. Altitude and climate
- e. Dust, sand, fungus, salt and air, and corrosive atmosphere
- f. Explosive atmosphere

Ventilation, Cooling. Specify availability of ventilating ducts and cooling devices such as fans to dissipate the heat generated by the solenoid. Give the ambient-temperature range. Since resistance of the solenoid coil varies with temperature and affects solenoid performance, specify any controls that are to be used for controlling temperature.

Environmental Conditions. Give any unusual environmental condition that the solenoid will encounter when in operation. Any of the environmental conditions listed will affect performance and life of the solenoid.

Matching Load Requirements

Knowing the load requirements, review the solenoid types and select the one type—plunger, clapper, helical, motor, or pivotal—best suited for your application.

Investigating Available Sources

Use the accompanying "Guide to Solenoid Suppliers" as a starting point; consult your purchasing department, advertisements or other sources.

Modifying Needs

If you decide there isn't a solenoid available that exactly fits your load requirements, you may have to adapt load to the solenoid that most closely meets the need. Discuss this problem with the manufacturer.

For REPRINT of above article, just check P52 on one of the Reader Service Cards bound in this issue.

EDITOR'S NOTE: For additional information on converting load motion, applicable to solenoids, see these past articles:

10 Ways to Change Straight-line Direction, Feb 29 '60, p 61. Arrangements are shown, using linkages, slides, friction drives and gears to change straight-line direction.

9 More Ways to Change Straight-line Direction, Mar 7 '60, p 59. Shown are gears, cams, pistons and solenoids, to change straight-line direction.

High-strength aluminum alloys, when clad with pure aluminum, gain up to 20 times their capacity to damp vibrational energy. Here's first data on . . .

DAMPING PROPERTIES of CLAD ALUMINUM

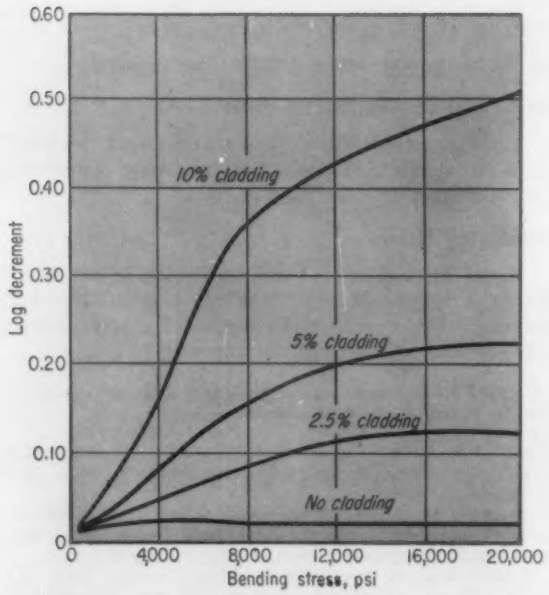
J G KAUFMAN
Mechanical Testing Div
Alcoa Research Laboratories

Cladding structural aluminum with a soft layer of the pure metal improves its damping capacity as well as its corrosion resistance. Although the cladding lowers tensile strength for a given section thickness, the added damping in a part also lowers stress caused by vibration. Tests on 2024-T3 clad with 5 and 10% pure aluminum show that damping capacity of this structural material can be increased up to 20 times.

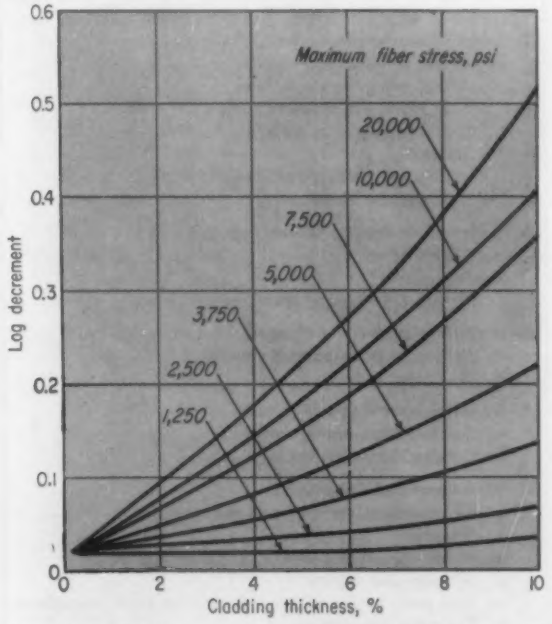
If vibration sources have a narrow frequency range, resonance can often be avoided by stiffening the structure and shifting the natural frequency of the part from that of the vibration. With random frequencies, however, this shifting of the resonance point does not work and vibrations must be damped to prevent them from building up large cyclic stresses. A simple method is to start with the material itself—selecting a material that inherently absorbs the vibratory energy will eliminate added costs of external damping such as dashpots and viscoelastic layers and inserts.

Although the structural aluminum alloys are not normally considered as having high damping properties (their specific damping capacity is about ½ to ⅓ that of cast iron), simply substituting the Alclad version of the same material will increase the damping capacity of the structure. The curves below show that cladding gives aluminum higher damping at higher stress levels. At stresses above

Soft Cladding Gives Damping to Aluminum Alloy 2024-T3



Damping effect increases with the max stress at outer fibers.



At surface, cladding gives damping proportional to thickness.

500 psi, 5% cladding gives 5 to 10 times as much damping capacity as the base material. The damping effect below 5000 psi is smaller, but 5% cladding still gives 1½ times as much damping at 625 psi, the lowest stress for which data could be considered reliable in these tests.

The log decrements—a measure of how fast the vibrations decay—shown in the curves were obtained for rectangular shapes and are roughly proportional to the amount of cladding. Cladding on other shapes would not necessarily be proportional. For example, cladding on a circular section will have a smaller effect because less of the cladding is at point of max stress. Actual amounts of energy absorbed, and whether a material damps the vibrations sufficiently, have to be determined empirically for each specific shape.

Alloy 2024-T3 was chosen for this test because in previous tests it showed damping characteristics typical of many aluminum alloys. The clad thicknesses—5 and 10% of total specimen thickness—were chosen to accentuate the effect of the cladding but are not standard for all commercial stock. Normal Alclads—off-the-shelf items—have 5% cladding for thin sheet under 0.63 in. and 2½% for thicker sheet or plate. Cladding also gives similar damping to all heat-treatable alloys clad with soft (non-heat-treatable) aluminum or alloys. These include the Alclad versions of X2020, 2024, 6061 and 7075. Alclad 2014 would exhibit less damping since it is clad with 6003, which hardens with heat treatment. The damping would also be less if the cladding is work-hardened either in forming the part or in making the Alclad sheet (for example: Alclad 2024-T36).

HOW IT RATES

Part of the test data for clad and unclad 2024-T3 are compared with other materials in Table I. The log decrements shown for decaying vibrations form a rough basis for comparison. If two materials have similar damping properties, other criteria such as yield or fatigue strength will determine the choice. Selection of the material may also be determined by part shape or fabricating properties.

THE FREE-VIBRATION TEST

The damping effects of the clad and unclad materials were compared by recording the free vibrations of cantilever-beam specimens. Specimens ¼ in. thick, and 2 in. wide by 18 in. long, were clamped—leaving 10 in. to vibrate freely. The system was vibrated by suspending a deadweight by a nylon string, then cutting the string.

Comparison of Damping Properties of Materials

This rating for materials was compiled with additional data from other sources. It is a rough guide showing average log-decrement values for free-decaying vibrations in cantilever beam specimens at 5000-psi max fiber stress. Methods used for exciting the initial vibrations differ but are assumed to have a negligible effect.

Material	Logarithmic Decrement
KIXI magnesium alloy	0.43
Aldad 2024-T3 (10%)	0.22
Manganese-Copper Alloy	0.20
Aldad 2024-T3 (5%)	0.10
Gray Cast Iron	0.05
AZ81A Magnesium Alloy	0.03
2024-T3 Aluminum	0.02
Mild Steel	0.02

Cladding Lowers Tensile Strength

Material	Ultimate Strength psi	0.2% Yield Strength, psi	Elong., %
2024-T3	69,000	43,100	21.2
2024-T3 (5% Clad)	64,000	40,000	21.2
2024-T3 (10% Clad)	60,600	40,800	22.0

The free-decaying vibrations were recorded with strain gages attached to each side of the specimens. The calculated log decrement is the natural log of the decrease in amplitude between successive vibrations. Nominal bending stresses, up to 20,000 psi, were computed from the full thickness of the specimens, neglecting the plastic behavior of the cladding material. A mathematical analysis showed that the error introduced is negligible. Only ¼-in. plate was tested, but the results obtained should be applicable to other sheet or plate with the same relative clad thickness.

EDITOR'S NOTE: Other articles on materials with high damping capacity and how to use them in controlling vibration:

Damping Tapes for Vibration Control, Jan 25 '60, p 57. A cheap, reliable and lightweight method to dissipate excess vibratory energy—keeping resonance stresses low. Basic equations and sample problem show how to calculate stresses in a square plate. This article is available as a reprint from our Reader Service Department for 25 cents.

Magnesium-Lithium . . . New Contender for Lightweight Champion, Oct 12 '59, p 74. Alloying magnesium with lithium offers 25% weight savings over conventional Mg alloys. Shows how high modulus-to-density ratio is helpful in shifting resonance frequency of an assembly.

Damping Capacity of Materials, Nov '54, p 164. A comparison of structural materials for their inherent effectiveness in absorbing vibration. Shows how to build damping into uniformly and nonuniformly stressed members.

Manganese-Copper — High Damping Alloys, May '56, p 135. Mechanical properties and potential applications of manganese-copper alloys that have unusual combinations of high tensile strength and damping capacity. Correlates specific damping capacity with the logarithmic decrement.

Latest Design Requirements for

BEARINGS AND LUBRICATION

An on-the-spot report brings you key design equations, charts and concepts presented at ASLE's Cincinnati meeting.

NICHOLAS CHIRONIS
Associate editor

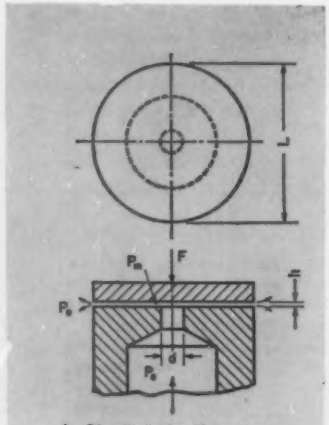
A simplified air-bearing design technique . . . new developments in journal and antifriction bearings . . . critical evaluations of lubricants . . . and a proposed new standard for machine-tool lubricants–these were the highlights of ASLE's annual meeting held last month in Cincinnati.

Many of the papers gave down-to-earth design recommendations; few got lost in mathematical manipulations–as can be noted from the summary below.

Numbers in the parentheses refer to papers; copies can be obtained from the American Society of Lubrication Engineers, 84 Randolph St, Chicago, at 75¢ per copy (50¢ to ASLE members).

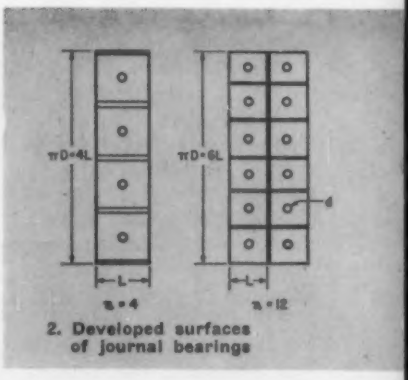
NEW AIR-BEARING DESIGN CURVES

A procedure developed by V. McNeilly of DuPont (60 AM 5A-2) simplifies the design of bearings lubricated by a film of compressed air. Said McNeilly, "Whenever a bearing is needed with vanishingly small friction–even at a standstill; a bearing that can operate at speeds limited only by bursting strength of the rotating member, that is immune to wide temperature extremes or the presence of radiation, that can maintain positional accuracies down to microinches, and that is free from fatigue, wear or seal problems—a pneumostatic (externally pressurized) bearing should be considered."



1. Single-hole thrust bearing

McNeilly starts with a simple, single-hole circular thrust bearing, Fig 1, as the "basic unit" for design. Here P_s is the supply pressure, P_a the exit pressure, P_m the pressure downstream of the orifice, F the force on the thrust bearing, and h the gap separated by air pressure. He develops equations and charts for finding the proportions of this type, then proceeds to modify the equations to pertain to a journal bearing. This bearing is made of a series of areas separated by channels to ensure that the areas act independently of each other, Fig 2. Each area has a small orifice to provide air fed from an annular manifold (not shown). Single or double rows of holes can be used.



2. Developed surfaces of journal bearings

The simplified design equations developed by McNeilly are:

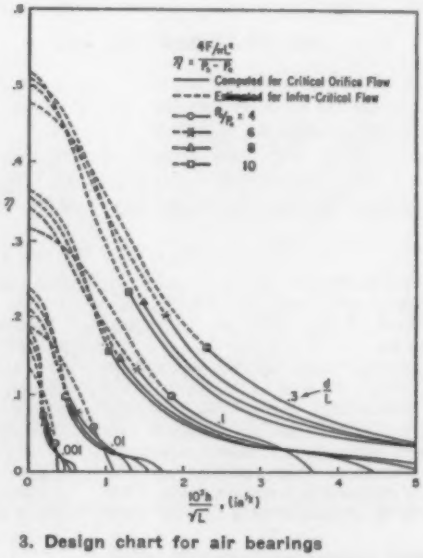
For a thrust bearing

$$\eta = \frac{4F}{\pi L^2 [P_s - P_a]} \quad (1)$$

$$Q = 75{,}000\, h\, d\, P_s \quad (2)$$

where L = dia of thrust disk (or length of a journal fed by one row of holes), d = dia of orifice, Q = airflow measured at P_s, η = the average bearing pressure divided by the supply pressure (gage).

Values of η can be obtained from the design curves in Fig 3, plotted for P_s/P_a ratios of 4, 6, 8 and 10.



3. Design chart for air bearings

Recommended Hole Layout for Various L/D Ratios

L/D Ratio	Rows of Holes	Holes per Row	Total Holes
0.2	1	15	15
0.4	1	8	8
0.6	1	5	5
0.8	1	4	4
1.0	2	6	12
1.5	2	4	8
2.0	3	5	15
2.5	3	4	12

For a journal bearing

$$W = \frac{A\,\pi^2}{8}\,(P_s - 14.7)\,(\eta_{h/2} - \eta_{3h/2}) \qquad (3)$$

$$Q = 75{,}000\,nhdP_s \qquad (4)$$

where n = number of inlet holes (see table), W = design load, A = projected area of journal and $\eta_{h/2}$ is the value of η at one-half the value of h (this assumes that shaft eccentricity is 50%). Gap above the shaft is then $3h/2$.

Design Problem

McNeilly shows how to design a high-speed idler roll (journal bearing) to carry a 1-lb load and how to determine its friction torque. The unit is not to consume more than 0.1 ft³/min. (172.8 in.³/min.), of free air.

Solution: Assume a ratio of 4 for P_s/P_a (the curves in Fig 4 are set up for ratios of 4, 6, 8 and 10). Since P_a = 14.7, then $P_s = 4(14.7) = 58.8$ psia.

From the table choose a length-diameter ratio of $L/D = 0.8$ so as to use a single row of four holes and thereby minimize η. Thus from Eq (4)

$$hd = \frac{172.8}{(75{,}000)\,(4)\,(58.8)} = 0.00001 \text{ in.}^2$$

The flow requirement is satisfied by making

$h = 0.001$ in.
$d = 0.010$ in.

Since $L/D = 0.8$, then $A = DL = 0.8D^2 = 1.25L^2$. Thus Eq (3) becomes:

$$L^2\,(\eta_{h/2} - \eta_{3h/2}) = \frac{8}{\pi^2\,(1.25)\,(58.8 - 14.7)} = 0.015 \text{ in.}^2$$

Taking trial values for L, it is found from Fig 4 that this condition is satisfied by $L = 0.34$ in. This gives a bearing with dimensions:

Diameter, $D = L/0.8 = 0.425$ (Use 7/16 in.)
Length, $L = 0.34$ (Use 3/8 in.)

Diametral clearance, 0.002 in.

Four inlet holes in the central plane, with a hole diameter of 0.010 in.

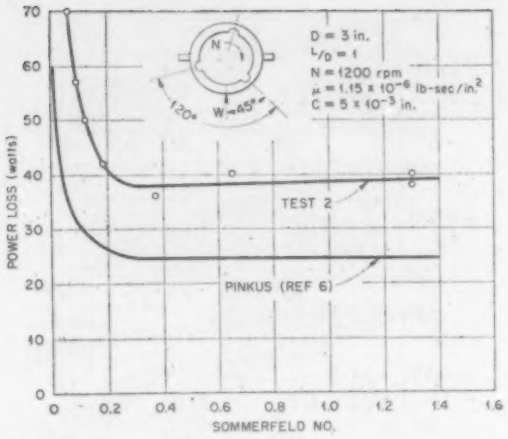
Supply pressure, 44 psig

Friction torque f can be computed from

$$f = \frac{0.0035\,D^3\,L\,(10^{-3}\,N)}{(10^2\,h)}, \text{ oz-in.}$$

$$f = (0.0035)\,(0.4375)^3\,(0.375)\,(10^{-3}\,N)$$
$$f = 0.00011\,(10^{-3}\,N) \text{ oz-in.}$$

Thus, for each thousand rpm of rotational speed, friction torque is 0.00011 oz-in. and corresponding friction coefficient is 0.000032 when carrying the 1-lb load.



4. Power loss in 3-groove bearing

THE THREE-AXIAL-GROOVE BEARING

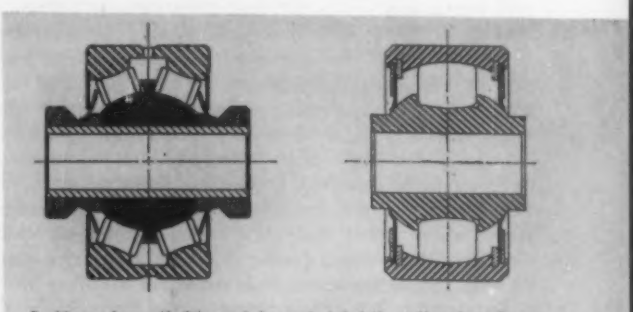
Tests by P. G. Smith of Oak Ridge National Laboratory (60AM 5A-3) on axial-groove bearings operating at 1200 to 1500 F indicate the two-groove axial type is unstable and susceptible to the whirl phenomenon. But bearings having three equally spaced helical grooves were found quite satisfactory when the discharge end of the grooves was restricted. Several sizes of grooves were investigated; an "intermediate" size gave best performance. Helical grooving appears satisfactory in any radial direction, but Smith recommends this should be investigated further.

Power loss varies with the Sommerfeld number. (Data on this was reported by O. Pinkus in an ASME paper, 1958.) Smith ploted this data, Fig 4, and then plotted a curve based on data from his Test 2. Power loss was higher, but followed the general trend.

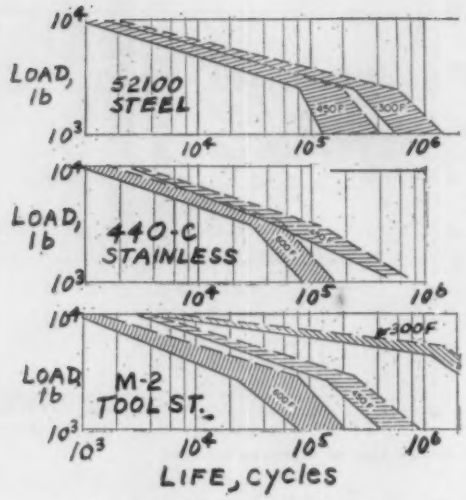
LIFE OF OSCILLATING BEARINGS

Performance of oscillating bearings is still quite unpredictable. Practical design equations have not been developed to date. However, tests are continually being performed, and their data aid the designer in predicting load-life characteristics.

W. A. Glaeser (60AM 3C-2) reports that over 1000 oscillating roller bearings, Fig 5, have been evaluated at elevated temperatures at Battelle Memorial Institute. The load-life characteristics were determined through statistical



5. Hourglass (left) and barrel (right) roller bearings



6. Load-life characteristics of oscillating bearings

analysis of failure data. Although tests were restricted to operating temperatures of 300 F, 450 F and 600 F, and to bearing materials of 52100 steel, M-2 tool steel and 440-C stainless steel, the compiled curves, Fig 6, should prove of wide use by means of interpolation.

The load-life charts are for ±35° oscillation. In general, bearing lives are longer when smaller amplitudes (±10°) are used.

Grease lubrication was essential for successful operation at all temperature levels. Bearings operating without grease failed in ☆ to ☆ the life expected for grease-lubricated bearings.

The hourglass roller design showed better high temperature capabilities than the barrel roller design. The latter fouled more easily by grease, was subject to roller skewing at high loads and high temperatures.

Bearing load range included 250,000 psi to 500,000 psi maximum Hertz stress. AISI 52100 steel proved satisfactory for temperatures to 450 F. Tool steel (M-2) and 440-C stainless proved satisfactory for temperatures to 600 F.

Failure Mechanisms

Three general types of failure were observed for oscillating bearings: spalling or flaking of the race and follower surfaces, accompanied by subsurface cracking; softening and plastic flow of the race and roller surfaces; oxidation, wear, and fouling by debris. Spalling was more evident in the longer lived bearings subjected to the lighter loads and at the lower temperatures. With higher load and temperature, the contacting surfaces roughened and roller edges tended to dig into the race surfaces. Hourglass rollers tended to extrude at heavy loads and high temperatures.

As might be expected, bearing life drops off as operating temperature goes up. Glaeser believes "droop" in the curves is due to two competing failure mechanisms—plastic deformation, which predominates at the heavier loads; and oxidation wear, which predominates at the lower loads.

Data scatter is less than that expected for continuously rotating ball bearings.

QUIETER BEARINGS

A high degree of resistance to plastic deformation at the contacts between rolling bodies and rings will result in quiet bearings. Tallian, Gustafsson, and Walp (60AM 2C-1) of SKF Industries show this resistance is primarily a function of material structure variables that affect the elastic limit.

Hardness, as measured by Rockwell or Diamond Pyramid methods is a primary variable but, in itself, an inadequate measure of this resistance. But resistance to plastic indentation is improved by appropriate heat treatment.

Influence of surface roughness and geometrical surface character on indentation susceptibility appears unlikely. The authors find no significant influence of surface roughness in several test series.

OIL-MIST LUBRICATION

Very little experimental information is available in the literature on oil-flow requirements of rolling-contact bearings under steady-flow conditions. Schuller and Anderson of the National Aeronautics and Space Administration (60AM 3C-3) have determined the minimum-oil-flow requirements of deep-groove ball bearings at DN values of 6×10^6 to 12×10^6, thrust loads of 1000 and 3000 lb, and temperatures to 500 F. In all the tests, a synthetic diester lubricant was supplied to the test bearings, Fig 7, in the form of an air-oil mist.

Temperature of a bearing operated at a constant load, without external heat addition, rises with increasing DN value. The authors derived an empirical formula that gives relationship of min oil flow, temperature and load:

$$T = 53.5 (\log Q + 2.38 \log W + 1.18)$$

where T is temperature, °F; Q is min oil flow below which failure would be imminent, lb/min.; and W is thrust load, lb.

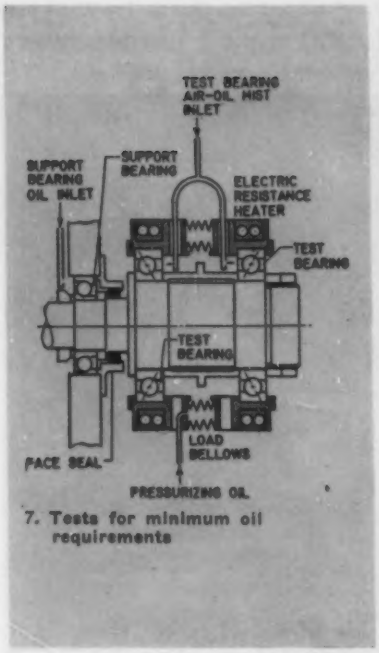
Bearings operated satisfactorily at very low oil flows using an air-oil mist, once-through system of lubrication. For example, it was possible to run size-215 bearings satisfactorily at 12,000 rpm (9.0×10^6 DN), 400 F, and a 1000-lb thrust load with oil flows as low as 0.003 lb/min. Also minimum-oil-flow requirements increased with increasing bearing temperature up to 400 F. At 500 F, varnish deposits on the bearing parts formed by the decomposing lubricant apparently aided lubrication and reduced the flow requirements below those at 400 F.

In the minimum-oil-flow range, bearing temperature and torque generally decreased as the oil flow was decreased—probably due to less heat generation through oil shearing.

CURRENT STATUS OF EP AGENTS

The term "extreme pressure" (EP) as applied to lubricants is often employed too loosely. Various elements such as fatty acids, soaps, phosphorous compounds, lead, chlorine and sulphur improve the load-carrying capacity of lubricants. E. S. Reynolds of Socony Mobile Oil Co. (60AM 3B-4) points out that by combining the basic materials, additives are possible which emphasize desirable properties and restrain the undesirable activities.

Organic phosphorous compounds are mild EP agents used extensively in lubricating oils to improve antiwear resistance. In some forms they act as catalyst deactivators to improve the oxidation stability of oils—particularly at elevated temperatures. Because they react only mildly with



7. Tests for minimum oil requirements

M.T.I.C. PROPOSED STANDARD LUBRICANTS

M.T.I.C. STANDARD IDENTIFICATION	VISCOSITY RANGE	TYPE	GENERAL APPLICATION	SHEET NO.
H-15	145-155 SUV	HYDRAULIC OIL STRAIGHT	HYDRAULIC SYSTEMS	1
HW-15	145-155 SUV	COMBINATION OIL FOR HYDRAULIC SYSTEMS AND LUBRICATION	HYDRAULIC SYSTEMS AND WHERE LUBRICATION OF LIGHT WEIGHT SLIDING MEMBERS IS REQUIRED	2
HW-30	300-320 SUV	COMBINATION OIL FOR HYDRAULIC SYSTEMS AND LUBRICATION	HYDRAULIC SYSTEMS AND WHERE LUBRICATION OF MEDIUM WEIGHT SLIDING MEMBERS IS REQUIRED	3
W-32	300-350 SUV	WAY LUBRICANT	LUBRICATION OF LIGHT TO MEDIUM SLIDING MEMBERS	4
WGL-90	850-950 SUV	WAY AND GEAR LUBRICANT	LUBRICATION OF MEDIUM TO HEAVY SLIDING MEMBERS - ALSO FOR GEARS INCLUDING WORM GEARS	5
S-3	30-32 SUV	SPINDLE OIL - LIGHT	LUBRICATION OF SPINDLES	6
S-5	50-60 SUV	SPINDLE OIL - MEDIUM	LUBRICATION OF SPINDLES	7
S-12	120-130 SUV	SPINDLE OIL - HEAVY	LUBRICATION OF SPINDLES	8
GL-30	275-325 SUV	GENERAL LUBRICANT	HAND OILING, OIL CUPS, ONE-SHOT SYSTEMS, ETC.	9
G-200	2000-3000 SUV	GEAR LUBRICANT	LUBRICATION OF GEARS	10

metal surfaces they do not usually show undesirable corrosive action.

Chlorine additives (chlorine is attached to the aliphatic carbon atoms) give lower wear and friction than those where chlorine is attached to an aromatic nucleus. Chlorine in cutting oils, in some gear lubricants and in other applications has proved very effective.

Sulphur additives combine with metal to form surface films that improve load-carrying properties. They are usually compatible with steel on steel, but can cause excessive staining or corrosion of nonferrous metals such as copper alloys.

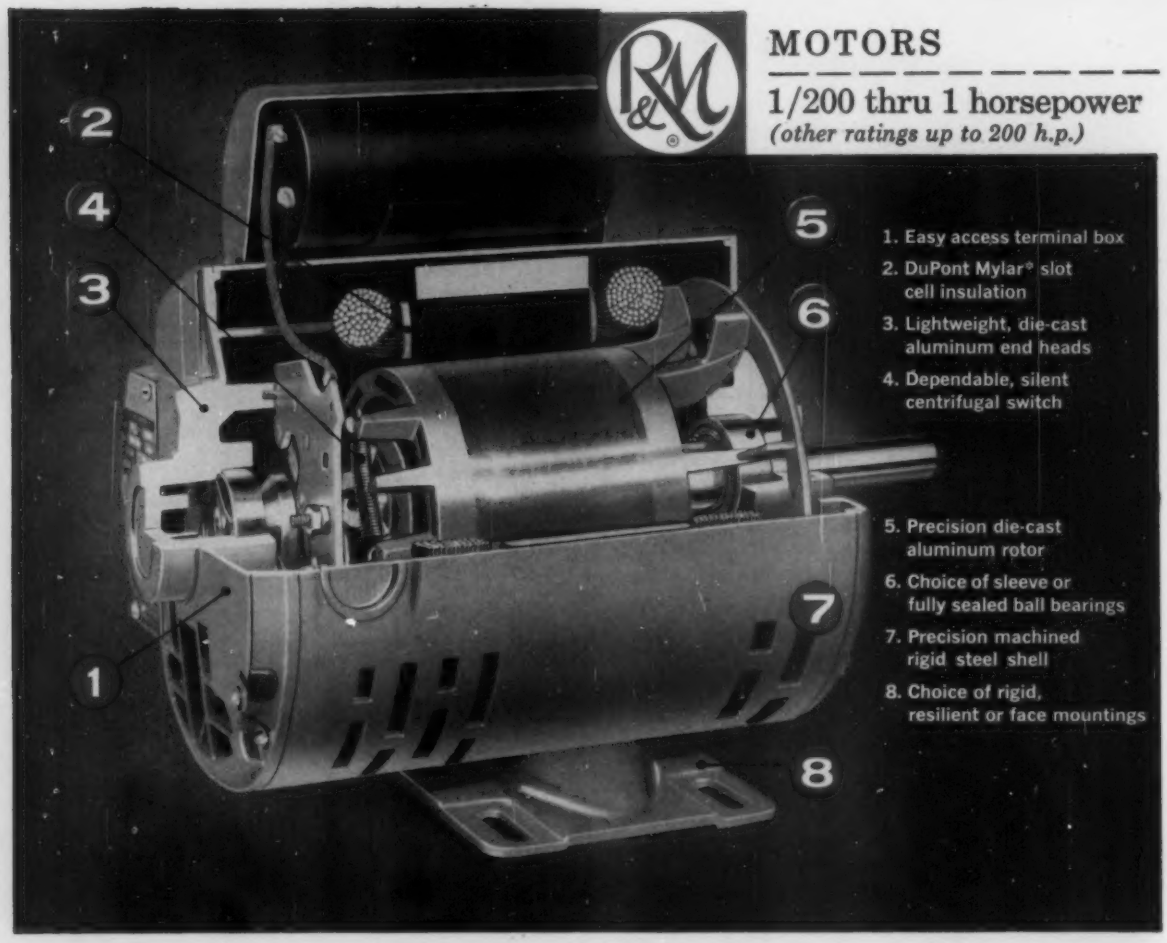
Lead-sulphur additives are effective in lubricants for heavy machinery. Current improved formulations use lead in a form such as lead naphthenate, to which an effective sulphur compound is added.

Two popular misconceptions are: (1) The greater the content of the additive, the better the results. Actually, the contrary may be true, because some EP agents adversely affect other significant properties of the lubricant such as demulsibility, stability, surface tension, tendency to form or corrode the surfaces. (2) The lubricant viscosity becomes insignificant in the presence of EP agents. Not true, because heavier viscosity of the fluid may affect not only the occurrence of boundary film conditions, but also the formation of full fluid films. Recent tests with spur and helical gears under boundary lubrication conditions show that between two EP lubricants, identical except for viscosity, it has been definitely established that is the higher viscosity product that carries more load.

PROPOSED STANDARD OF LUBRICANTS

An ASLE council representing the machine-tool industry is considering the adoption of conventional-type specifications which spell out chemical and physical properties. M. W. Papp of Warner & Swasey reports (60AM 6B-2) such specifications have been prepared for 10 types of fluid lubricants most commonly used in the machine-tool industry. The above table summarizes the lubricants and their applications. A proposed standard identification number has been assigned to each lubricant. Once these identifications have been accepted and securely established, the council hopes machine-tool builders will have a simplified language for conveying lubricant information to customers, suppliers and other interested parties. Each identification number will be completely defined in terms of chemical and physical properties.

Possibly the major disadvantage of a specification such as this, Papp points out, is its restriction of certain factors that have an unestablished and highly questionable significance. In other words, it implies that the only lubricants suitable for use in hydraulic systems of machine tools have all of the properties, and only those properties, defined by the specification. Yet it is recognized that minor deviations have little bearing on the usefulness of lubricants. ■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(other ratings up to 200 h.p.)
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2. DuPont Mylar® slot cell insulation
3. Lightweight, die-cast aluminum end heads
4. Dependable, silent centrifugal switch
5. Precision die-cast aluminum rotor
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8. Choice of rigid, resilient or face mountings

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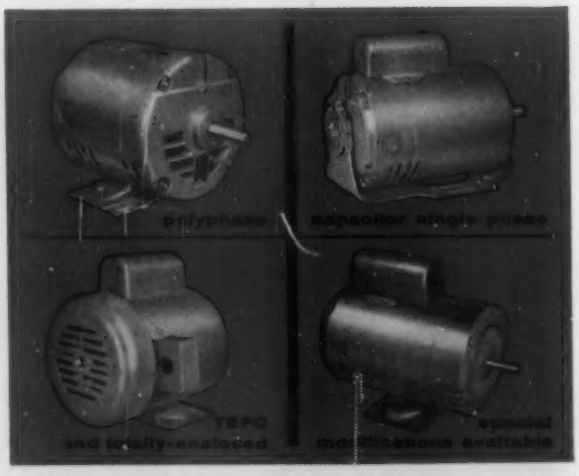
**DuPont registered trademark*



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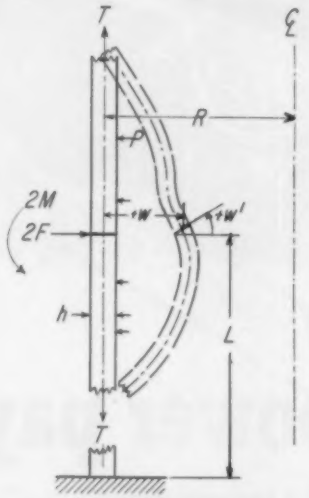
WHEN THIN-WALL CYLINDERS CARRY THE LOAD . . .

. . . these new equations give quick answers for stress and deflection caused by skirts or reinforcing rings.

ROBERT I ISAKOWER, *ordnance engineer, Picatinny Arsenal*



SYMBOLS

E = Young's modulus, psi
e = external-load moment arm, in.
$2F$ = radial load, lb per in. of circumference
h = cylinder-wall thickness, in.
K = ratio, R/h
L = distance to point of restraint, in.
$2M$ = moment, in.-lb per in. of circumference
P = internal pressure, psi
R = mean cylinder radius, in.
T = axial membrane load, lb per in. of circumference
w = radial displacement, in.
w^1 = rotational displacement, radians
μ = Poisson's ratio
σ_θ = hoop stress, psi
σ_a = axial stress, psi
$\phi_{1,2,3}$ = equation factors

For accurate results: $K \geq 10$, $L \geq \frac{5}{\beta}$,

where $\beta = \frac{3(1-\mu^2)}{\sqrt{Rh}}$

Thin-wall cylinders often act as structural members or as supports for external loads. These loads are transmitted to the cylinder through rings, skirts, clips or guy-wire supports. Stresses and deflections in the cylinder depend on internal pressure as well as external moments and radial loads.

Calculating these values usually involves time-consuming simultaneous equations. But the new equations presented below give answers faster, and with less chance for error. The key: three factors that eliminate many of the calculations ordinarily needed. These factors, ϕ_1, ϕ_2, and ϕ_3 are charted for various values of Poisson's ratio on the continuing page.

1. **Stresses** (add for inner fiber; subtract for outer)
Axial:

$$\sigma_a = \frac{T}{h} = \frac{6}{h^2}\left[\sqrt{Rh}\,\phi_1 F + M\right]$$

Hoop:

$$\sigma_\theta = PK = \frac{\mu 6}{h^2}\left[\sqrt{Rh}\,\phi_1 F + M\right] - \frac{\phi_2 K^{1/2} F}{h}$$

2. **Displacements**
Radial:

$$w = (K^{3/2}\phi_2 F - PRK + \mu TK)/E$$

Rotational:

$$w^1 = \frac{K^{1/2}\phi_2 M}{h^2 E}$$

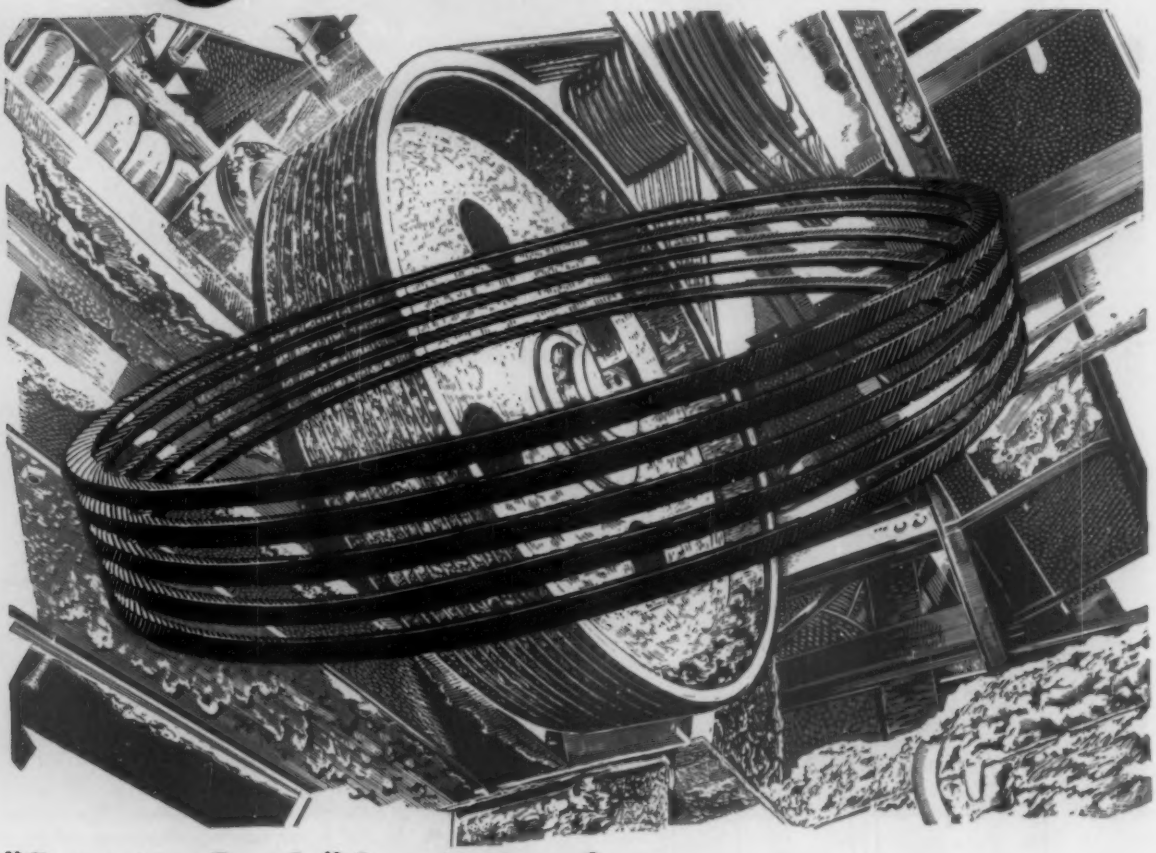
$$T = \frac{PR}{2} + T_{\text{external}}$$

EXAMPLE: A steel cylinder with a support skirt has $T_{\text{external}} = 0$, $P = 0$, $R = 10$ in., $h = 0.20$ in., $\mu = 0.30$, $E = 30 \times 10^6$ psi, $e = 1.0$ in., $2F = 60$ lb/in.

SOLUTION: $2M = (2F)e = 60$ in.-lb/in.
From chart, $\phi_1 = 0.3891$, $\phi_2 = 1.2865$, $\phi_3 = 4.2488$

continued on page 63

U.S. RUBBER **U. S. ROYAL V-BELTS** from the Power Unlimited complete belt line



"Swinging Loads" demonstrate how

balanced driving power pays off

The flywheels on stone-crushing machinery at the Bethayres Concrete Products Company in Bethayres, Pa., put V-belts under a "tremendous strain."

Not only must each set of 8 U. S. Royal V-Belts driving the flywheel operate under extremes of abrasive conditions, it must also operate on constantly changing centers. As incompressible foreign matter enters the driven rollers, they swing or oscillate to allow passage. The result is constantly changing tensions under pressures amounting to many tons!

Yet even with this constant change in tensions and the severity of the abrasive conditions, the U. S. Royal V-Belts continue to share the load for an average of one year of rock-breaking service.

The C-210's used on these V-sheave to flat-surface drives, like all of the approximately 250 "U. S." belts in 48 different sizes used throughout the Bethayres plant, have a built-in advantage. "Balanced driving power"... the result of specially developed manufacturing equipment that automatically controls weight, dimensions, density, length, and tension members... helps provide a uniformity, toughness, length stability and true-running smoothness that have paid off in job after job, plant after plant the nation over.

Put balanced driving power to work in your own operations. See your "U. S." Power Transmission Distributor for full stocks and expert service.

U. S. Royal V-Belts and engineering assistance for these drives supplied by "U. S." Distributor Lindsay-Oberholzer of Philadelphia, Pa.

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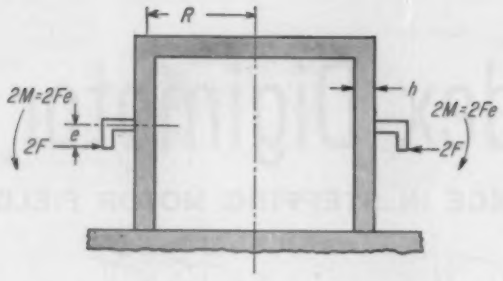
THIN-WALL CYLINDERS continued



Stresses

Axial:

$$\sigma_a = \frac{0}{0.20} \pm \frac{6}{(0.20)^2}\left[\sqrt{10(0.20)}\,(0.3891)30 + 30\right]$$

$$= \pm 6975 \text{ psi}$$

Hoop:

$$\sigma_\theta = 0 \times 50 \pm 0.30\,(6975) - \frac{1.2865\ \sqrt{50}\,(30)}{0.20}$$

$$= -3456 \text{ psi inner fiber}$$
$$= +750 \text{ psi outer fiber}$$

Displacements

Radial:

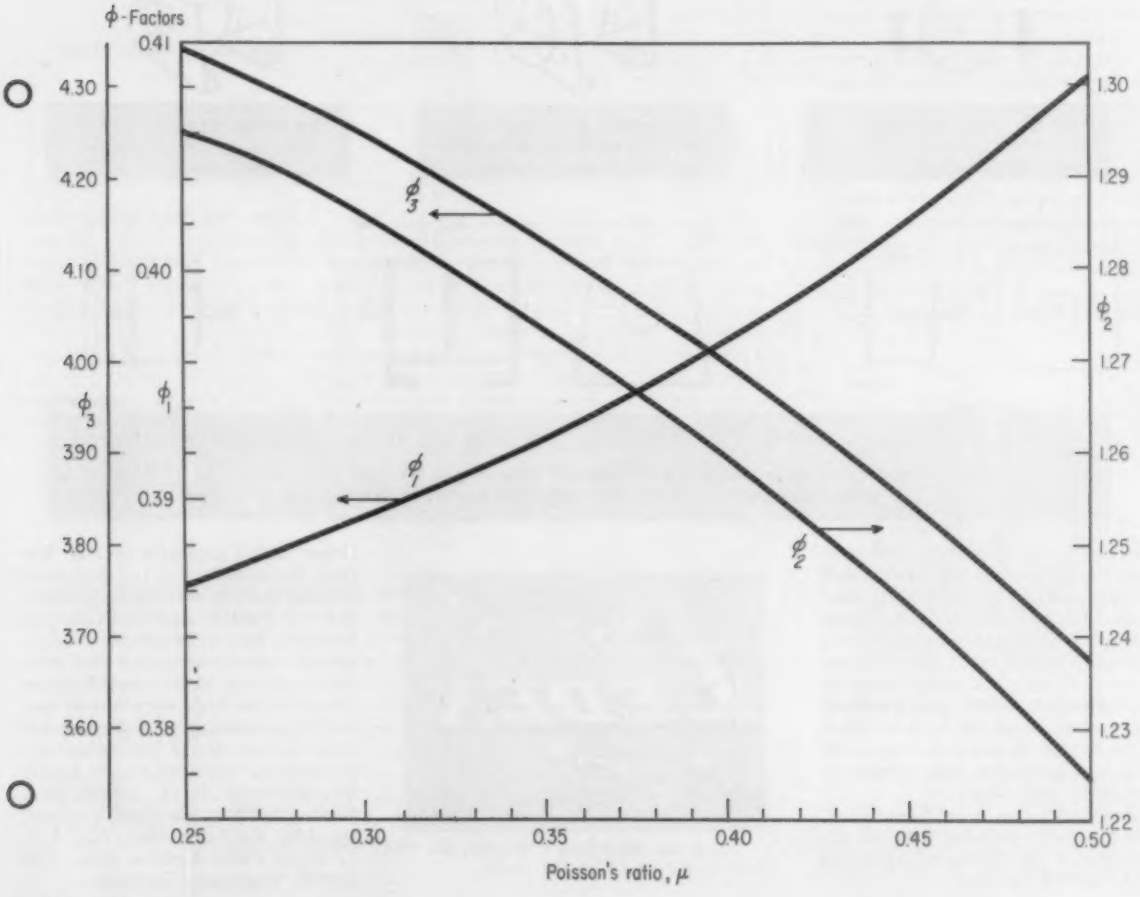
$$w = \frac{(50)^{3/2}(1.2865)30}{30 \times 10^6} - \frac{0 \times 10 \times 50}{30 \times 10^6}$$

$$+ \frac{0.30 \times 0 \times 50}{30 \times 10^6} = 4.50 \times 10^{-4} \text{ in.}$$

Rotational:

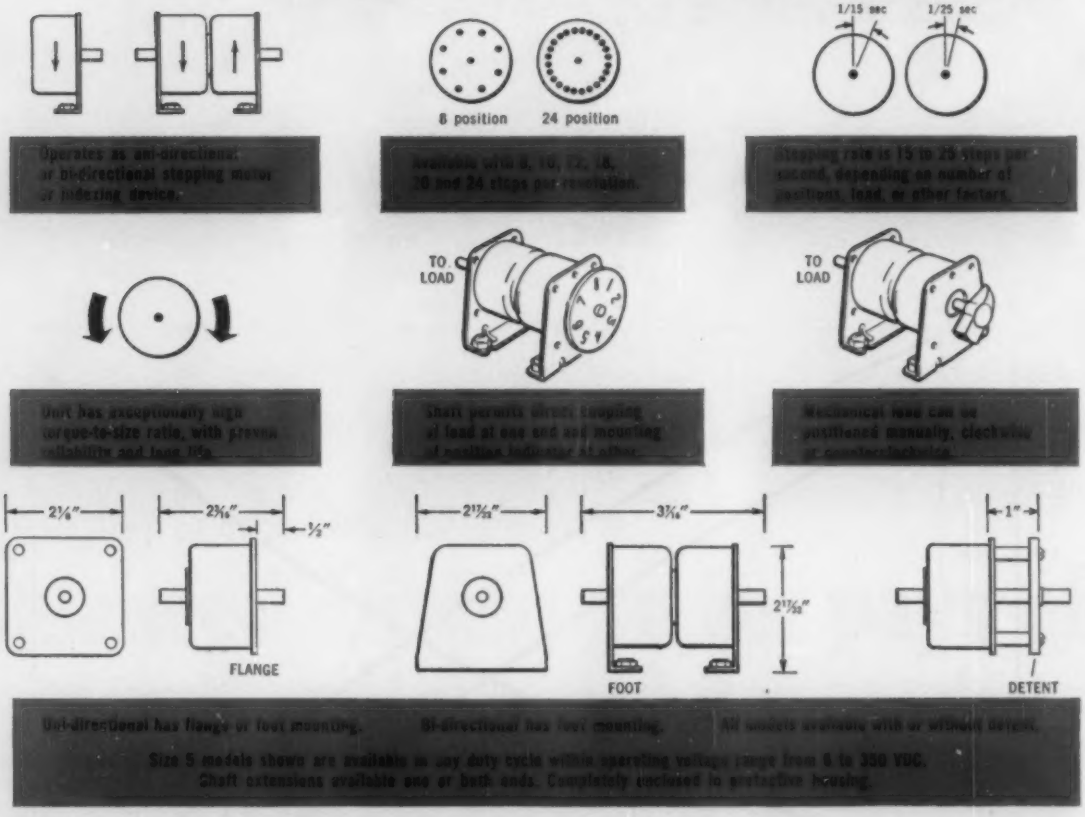
$$w' = \frac{\sqrt{50}\,(4.2488)\,30}{(0.20)^2\,30 \times 10^6}$$

$$= 7.49 \times 10^{-4} \text{ radians}$$



New Ledex Digimotor®

IS MAJOR ADVANCE IN STEPPING MOTOR FIELD



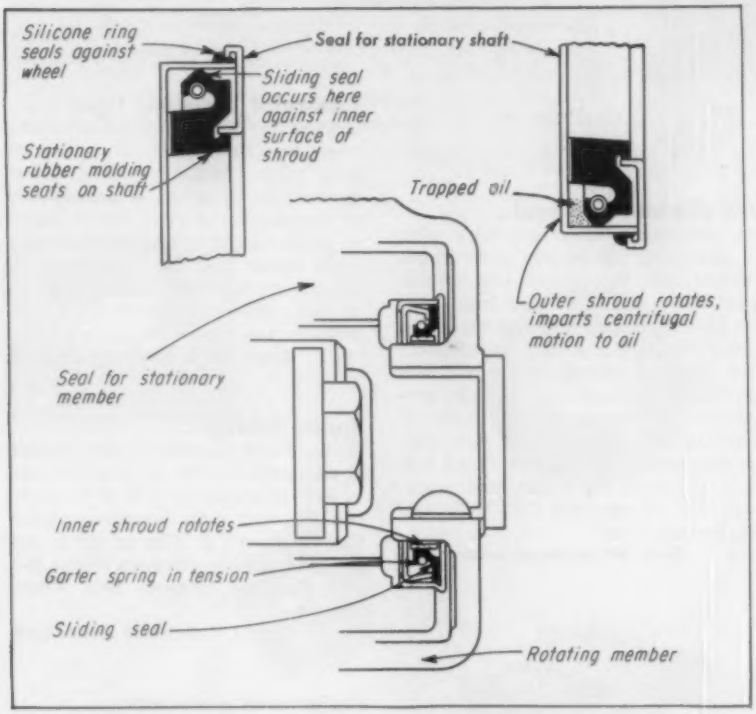
The new Ledex *Digimotor* is a stepping motor or indexing device with exceptionally high reliability and torque-to-size ratio. Its new design concept gives it features never before available. Size 5 stock models come in a variety of shaft positions and in any duty cycle within a wide operating voltage range. It is jam proof, permanently lubricated, has magnetic anti-overcoast, and operates at "whisper" noise level.

New Ledex *Digimotor Switches* are rotary selector switches with all advantages of the Digimotor drive plus other special features.

Ledex, Inc. was formerly G. H. Leland, Inc.

Other Ledex products include Rotary Solenoid, Rotary Solenoid Selector Switch, Hermetically Sealed Selector Switch, and *Syncramental* Stepping Motor. Mechanical applications include actuation of valves, vanes, printers, shafts. Switching applications include circuit selecting, stepping, counting, programming and sequencing. Write for literature, mentioning application, to Ledex, Inc. (formerly G. H. Leland, Inc.), Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; NSF GmbH, Nurnberg, Germany.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES


Silicone ring seals against wheel
Seal for stationary shaft
Sliding seal occurs here against inner surface of shroud
Stationary rubber molding seats on shaft
Trapped oil
Outer shroud rotates, imparts centrifugal motion to oil
Seal for stationary member
Inner shroud rotates
Garter spring in tension
Sliding seal
Rotating member

Self-contained oil seal . . .
provides not only seal itself, but also surface against which sealing action occurs. In previous design, seal was effected at shaft surface and even minute imperfections on shaft surface accelerated wear. Shaft rotation increases lubrication of rotary sliding surfaces of seal, which is composed mainly of outer shroud and inner rubber molding. When mounted on truck wheel, outer shroud is press-fitted into wheel bore; inner rubber molding is push-fitted on stationary shaft. Because there is no relative motion of shaft and rubber molding, finish grinding of shaft not required. For applications where shaft rotates in stationary bore, shroud is located on inner (shaft) side and is mounted on shaft either by press-fit or over rubber sleeve. Because no centrifugal motion is imparted, oil starvation cannot occur. Can be made for operation to 500 F. Slightly more expensive than standard shaft seal. Delivery depends on quantity and tooling. **Chicago Rawhide Mfg Co, 1301 Elston Ave, Chicago 22.**

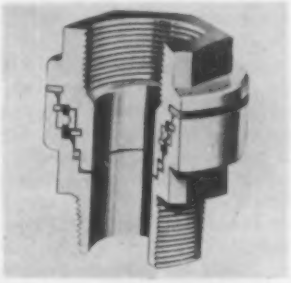
Circle 300 on Reader Service Card

Hydraulic-magnetic tripping element . . .
is used in circuit breakers that can be supplied in 360 standard current ratings from 0.020 to 50 amp, or in any fractional rating within these limits. Available in standard, fast and instantaneous trip ranges. Standard or general-purpose time delay is said to be applicable to protection of motors and for wiring. Fast time delay has been designed to protect electronic circuits. For special applications that require immediate response, breakers can be supplied without time-delay element. Offered in voltage ratings of 32 or 50 v dc and 125 or 250 v at 60 cps. Interrupting capacity of breakers ranges from 1000 to 3000 amp, depending on voltage rating. Unit is enclosed in hot-molded, phenolic-resin case. Breaker is sealed at factory and cannot be held closed under fault conditions. Price is $12.60 for 1 to 50 amp ratings; $15.55 for 0.020 to 1 amp. Delivery, 4 wk. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 22.**

Circle 301 on Reader Service Card

Relay has built-in neon indicator lamp . . .
connected in series with resistor; both components are connected in parallel to relay coil to determine availability of current. Transparent cellulose acetate dust cover provides operating visability for lamp and contacts. General-purpose relay can be furnished in production quantities for operation at 6 to 110 v dc and 6 to 230 v ac. Silver cadmium contacts rated at 10 amp are standard for ac and dc models; silver contacts are rated at 5 amp. Contact arrangements are available up to 3PDT. Over-all dimensions, not including plug, are 2 x 1$\frac{13}{16}$ in. sq. **Potter & Brumfield, Princeton, Ind.**

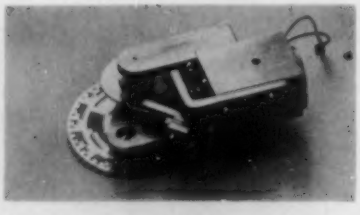
Circle 302 on Reader Service Card



Ballbearing hose swivel . . .
is said to revolve freely at pressures up to 125 psi and temperatures to 225 F. Can be used to make piping and tubing flexible or movable, or as swivel connectors on hose to eliminate damage due to twisting. Said to withstand severe radial and thrust forces. Available in 1$\frac{1}{4}$ and 1$\frac{1}{2}$ in.

sizes, swivel is made leakproof by Buna-N ring. Constructed of bronze and aluminum. Ballbearing races are locked in by snap rings without hindering swivel action. **OPW-Jordan, 6013 Wiehe Rd, Cincinnati 13.**

Circle 303 on Reader Service Card



Miniature sequence programer

is solenoid-actuated switching device to encode or decode events in sequence. Designed for operation with solid-state circuitry over wide range of input rates. Employs interchangeable coded disk to determine or sense sequence of events. Program disk can be divided for sequences requiring up to 100 switch positions. Complete unit is less than 1¾ in. long and weighs 0.9 oz. Rated for 4 to 8 v and will operate with input pulses as short as 11 millisec up to 70 indexing motions per sec. Withstands temperatures of —40 to 165 F, vibration at 10 g from 5 to 55 cps, and shock at 15 g, 11 millisec duration, in accordance with MIL-E-5272. **Elgin Micronics, Div Elgin National Watch Co, 366 Bluff City Blvd, Elgin, Ill.**

Circle 304 on Reader Service Card

Multiratio gear reducer . . .

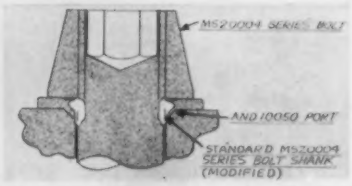
is miniature unit offering over 70 reduction ratios. Ratio changes are made through pickoff change gears. Comes assembled in wooden storage container with change gears for 24:1, 40:1, 60:1, 120:1, 240:1, 260:1 and 600:1 ratios. Additional change gears are available from stock to produce total of 73 different reduction ratios. Gear reducer has max rated output torque of 130 in.-oz; operating load torque of 65 in.-oz and starting torque of 0.02 in.-oz max. Backlash is 30 min. maximum. Weighs about 12 oz. Priced under $300. **Great Eastern Mfg Co Inc, PO Box 121, Springfield, Vt.**

Circle 305 on Reader Service Card

Protective coatings . . .

said to exhibit high chemical, solvent and abrasion resistance are made of polysulfide liquid polymers and epoxy resins. Liquid polymers form flexible, elastomeric films; epoxy resins provide hard, chemical-resistant films. Epoxy coatings are available in several formulations from solvent systems to 100% solids. Most coatings cure over broad temperature range to 40 F min. **Cosden Paint Co, Beverly, NJ.**

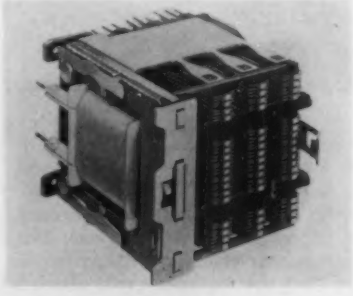
Circle 306 on Reader Service Card



Metal-bolt head seal . . .

for installations where removable plate is attached to high-pressure vessel, affords high-strength, high-pressure joint capable of holding up to 10,000 psi at from —400 to 1800 F. Seal has heel wide enough to accept bolt tension preload. Relief under bolt head and chamfer around bolt hole are also provided. Sealing of bolts connecting directly to pressure vessel is achieved by using standard port seal, putting standard AN chamfer around bolt hole and improving surface finish under bolt head. **Harrison Mfg Co, 739 N Lake St, Burbank, Calif.**

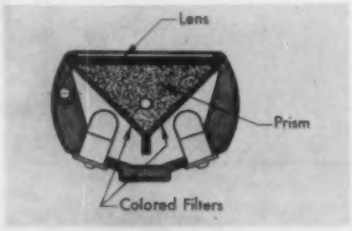
Circle 307 on Reader Service Card



Wire-spring relay . . .

can transfer up to 51 circuits for 100 million or more operations without readjustment. Actuating card, activated by armature movement, operates moving wire-spring contacts simultaneously and independently. Accumulative buffer wear is avoided. Movable springs are aligned and anchored in molded assembly. Plastic comb aligns stationary springs of relay. Available in one, two or three levels of contact assemblies with up to 17 form-C combinations each. Operating voltages range from 6 to 220 v dc. Rectified ac is also accommodated. Largest contact pile-up requires less than 4 w operating power. Weighs about 2.25 lb. Full 51-circuit, three-level relay sells for about $50. **Automatic Electric Laboratories, Northlake, Ill.**

Circle 308 on Reader Service Card



Two-color indicator light . . .

provides two different colored indications where legend or function is common to both colors. Feature, available in 44 standard configurations, is accomplished by incorporation of prism that is shaped to produce uniform light dispersion over entire legend areas. Rotating lamp capsule permits bulb replacement without use of tools. **Master Specialties Co, 956 E 108th St, Los Angeles 59.**

Circle 309 on Reader Service Card

Epoxy tubing . . .

in commercial quantities is now available in sizes from 0.150 to 0.750 in. OD and in wall thicknesses of 0.150 to 0.032 in. Available with heat distortion temperatures up to 465 F. Can be cut to any length up to 50 in. **Magnolia Plastics Inc, 5547 Peachtree Industrial Blvd, Chamblee, Ga.**

Circle 310 on Reader Service Card

Motor tach generator . . .

in size 11 for damping in position servo and similar applications withstands temperatures from —67 to 257 F. Leads are exited from side. Motor has 6000 rpm min no-load speed; 0.6 in.-oz min torque at stall at 77 F; 1.3 gm-cm² rotor moment of inertia; 3.5 w per phase stall power. This 115-v, 400-cps generator has 3.05-w input; output voltage of 0.5 v per 1000 rpm min at 77 F; 10° max phase shift and 1200-ohm output impedance. **John Oster Mfg Co, Avionic Div, 1 Main St, Racine, Wis.**

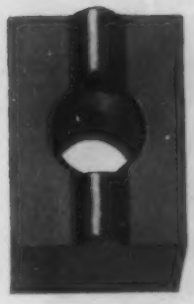
Circle 311 on Reader Service Card

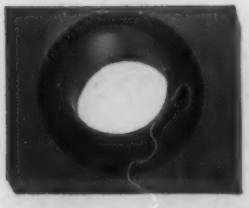
Hydraulic-power units . . .

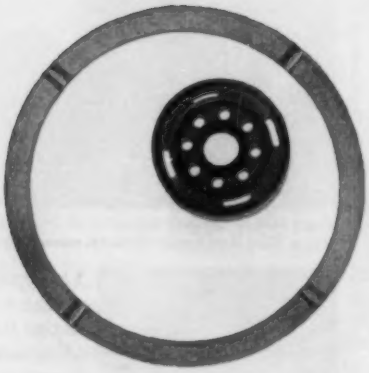
are air-operated and offer hydraulic pressures from 500 to 30,000 psi. Built-in pilot valve is said to effect positive operation under all running conditions. Designed for oil and water service in operating hydraulic equipment and static- and burst-pressure testing, units are offered in one series with 10 models from 500 to 25,000-psi hydraulic pressure and another series with eight models from 1000 to 30,000-psi hydraulic pressure. Provide capacities from 3 gpm at 500 psi to 20 cu

continued on page 69

ACCURACY, DURABILITY and ECONOMY are important characteristics of these sintered metal automotive suspension parts by Delco Moraine. Vital components such as these are typical results of close collaboration between Delco Moraine and its customers—an effective liaison that functions from idea through design and development to production. They also confirm Delco Moraine's equally important capabilities for making deliveries in quantity and on time!







DELCO MORAINE

DEPENDABLY MADE parts for industrial progress • Division of General Motors, Dayton, Ohio

CIRCLE 67 ON READER SERVICE CARD

SAVE MONEY
on parts like these!

Specialized equipment and design skill give us an edge in trimming costs. Send us a sample or description, plus quantity, for an eye-opening quotation. Address: The American Brass Company, Fabricated Metal Goods Division, Waterbury 20A, Connecticut. 60177

ANACONDA®

MULTIPLE-PLUNGER PRESS PRODUCTS

Guaranteed free from defects

Every inch of fabric is inspected for defects before coating operations are begun. Here the operator is shown removing slubs.

Close up of a weaving imperfection being removed by burling.

The burling operation is one of the numerous inspections in the Reeves Vulcan system of quality control. This inspection is made on every roll of fabric before it is coated. Whatever the application, we can assure you that Reeves Vulcan coated fabrics will safely meet published specifications.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Div. 1071 Avenue of the Americas, New York 18, N. Y.

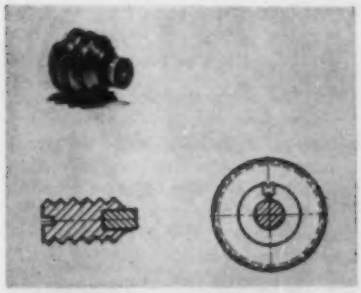
in. per min. at 30,000 psi. SC Hydraulic Engineering Corp, 14032 S Avalon Blvd, Los Angeles 61.

Circle 312 on Reader Service Card

Flexible, flame-resistant hose

for air-handling and fume-control applications, has operating temperature range of —40 to 300 F. Said to have high burst strength. Made of neoprene-coated glass fabric, it is spiral-wire reinforced. Available in sizes from 1½ to 24 in. ID. Stock sizes, 2 to 12 in., range in price from $1.20 to $4.35 per ft. Flexaust Co, 100 Park Ave, New York 17.

Circle 313 on Reader Service Card



Setscrew with nylon tip . . .

is available with slotted head or socket head in sizes from 2-56 to ¼-20 and in variety of stock lengths. When applied in gear or hub and tightened to basic shaft, nylon tip protects shaft from marks or mars and has full-face contact rather than two-point contact. When locked in place, nylon material takes shape of curved shaft and imbeds itself in thread hole. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY.

Circle 314 on Reader Service Card

Shear-seal valves . . .

are cylinder-operated and rated for 10,000, 6000 and 3000 psi hydraulic oil or water and 10,000, 4000 and 2000 psi air. Available in four- or three-way and shutoff flow patterns. Port sizes range from ¼ through 1½ in. NPT. Operators are obtainable with cushioned or noncushioned cylinders for 80 to 250-psi air pressure and for 500-psi max oil or water pressure. Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58.

Circle 315 on Reader Service Card

General-purpose filters . . .

for filtration of most fuels, lubrication oils, hydraulic fluids, air and other gases and liquids has pore-size ratings from 2 to 100 microns. Available with five different element materials. Over-all temperature range covered by elements is —350 to 350 F. Flow rate and pressure-drop ratings for filters depend upon filter-element materials and fluids to be filtered. Filter assemblies have rated operating pressure of 150 psi with burst pressure of 600 psi. Housings are aluminum. Bendix Filter Div, Bendix Aviation Corp, 434 W 12 Mile Rd, Madison Heights, Mich.

Circle 316 on Reader Service Card

1/100 to 1/3-hp ac motors . . .

for special applications are offered in 16 horsepower ratings, based on open-ventilated operation, 104-F rise, constant speed and continuous duty at 115 v, 60 cps. Fans in motor's double-end ventilating system are cast integrally with rotor. Fractional Horsepower Motor Div, Robbins & Myers Inc, Springfield, Ohio.

Circle 317 on Reader Service Card

Tube-cooled motors . . .

ranging up to 2000 hp are built in standard enclosed construction for nonhazardous locations and in explosionproof construction with UL Class 1, Group D label for hazardous locations. Tube-cooled air-to-air heat-exchanger motors operate in unfavorable environmental conditions, protecting against excessive moisture, oil vapor, chemicals, alkalis, coolant and airborne dust, sand, dirt and metallic particles. Features include capsule-type split-sleeve bearings and pressure lubricating systems with oil-level indicators. Louis Allis Co, Dept P, Milwaukee 1.

Circle 318 on Reader Service Card

Enclosed, flat-type motors . . .

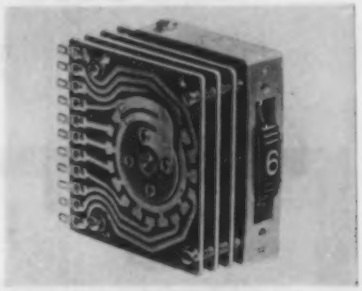
in nonventilated and fan-cooled models, with ranges of ½ to 7½ hp and ¼ to 10 hp, respectively, have been acquired from Diehl Mfg Co. Both types are available with flange, face and special mountings in wide variety of voltages and speeds. Some models are said to weigh less than half as much as equal-hp conventional NEMA design B motors and to be as much as 48% shorter. Howell Electric Motors Co, Howell, Mich.

Circle 319 on Reader Service Card

Flexible steel conduit . . .

with polyvinyl chloride synthetic resin cover, has UL approval for use as protection for electrical wiring in wet areas. Also equipped with copper-wire positive ground. Absorbs vibration and resists flame, oil, grease, dirt, chemicals, fumes and salt spray. Sizes ⅜, ½ and ¾ in. incorporate square locked construction and extra-heavy, galvanized steel core. Sizes 1 and 1¼ in. have fully interlocked galvanized steel core. International Metal Hose Co, Bellevue, Ohio.

Circle 320 on Reader Service Card



Multideck rotary switch . . .

offers eight, ten or twelve positions. Available with two, three or four printed circuit modules, which consist of any combination of binary and digital rotary thumbwheel switches, all manually operated by single ¼-in. Delrin thumbwheel. One white or red number is exposed at a time through bezel opening. Numbers can be lighted. Standard units are available immediately: lighted types in 60 days. Chicago Dynamic Industries Inc, Precision Products Div, 1725 Diversey Blvd, Chicago 14.

Circle 321 on Reader Service Card

Silicone rubber-to-metal seal

on gaskets is said to resist swelling normally caused by solvents, jet fuels and oils. Said to provide excellent seal for fluids in temperatures down to —80 F and to be comparable, in many respects, to other fluorinated elastomers at temperatures to 450 F. Stillman Rubber Co, 5811 Marilyn Ave, Culver City, Calif.

Circle 322 on Reader Service Card

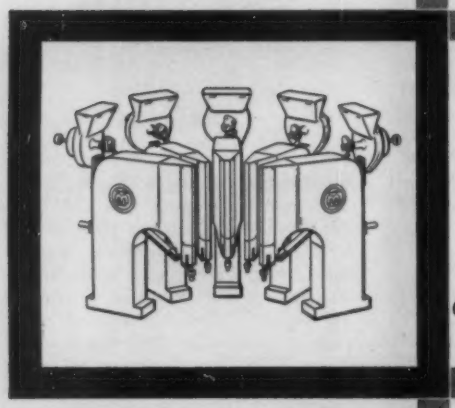
Ac electromechanical pickups

of the linear, variable-differential, transformer type have been introduced in three models. Used for measurement and control, transducers provide proportional ac output in sensing linear displacement. With excitation voltage of 1 to 10 v ac, carrier frequency ranges from 400 cps to 3 kc. Adaptable for temperatures from —65 to 250 F. In linear range of 1 to 4 in., transducers have nonlinearity of 0.5% or less. Sensitivities in milliv output per input volt per 0.001 in. are 1 for smaller model to 0.25 for largest, when operated from 1-kc carrier. Resolution is continuous and repeatability is said to be

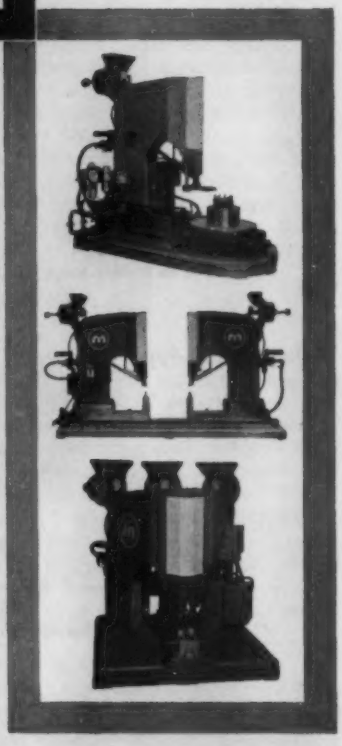
continued on page 70

NEW "BUILDING BLOCKS"

... for automatic riveting



Milford's Models 56 and 57 offer unlimited flexibility in automatic assembly



The narrow wedge shape of Milford's new air-actuated riveters permits unusually close riveting. Both models can be combined with sliding-fixtures, indexing tables or similar attachments to give greatest flexibility of assembly. Air-operated toggle action assures fast and safe action. Model 56 handles tubular rivets from ⅛" diameter x ⅝" length; Model 57 from 3/16" diameter x 3/4" length.

Group these new "Building Blocks" to suit your own production needs. Use them singly, in pairs, in threes, fours or even fives. Multiple riveting is the newest answer to reducing production costs.

For more new ideas, tips and technical data on tubular rivets and rivet-setting machines, ask your Milford Representative for a look at Milford's new MANUAL OF MODERN RIVETING PRACTICE.

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

0.01% or better. Made of stainless steel and encapsulated with inert epoxy resin. Pacific ElectroKinetics, 329 S Vermont Ave, Glendora, Calif.

Circle 323 on Reader Service Card

High-overpressure transducers

with ranges from 0-25 to 0-300 psi are reported to withstand overpressures of 1500 psi without shift or damage. Sensor design is said to require no auxiliary cut-off valving arrangement. One model has internal structure in configuration of 2¾ x 3 in., that is suited for differential-pressure measurement applications involving introduction of high pressures both to sensor and to instrument case. Available with potentiometric outputs. Delivery, 8 to 10 wk. White Avionics Corp, Terminal Rd, Plainview, NY.

Circle 324 on Reader Service Card

50 in.-oz synchronous motor . . .

is permanent-magnet ac unit said to be suited for applications requiring constant, 72-rpm synchronous speed and/or dc stepping with instant starting, stopping or reversing. Rated for input of 120 v, 40/70 cps, single-phase, 0.30-amp max current at 60 cps. Temperature rise is 167 F from 104 F max ambient under continuous duty. Standard types are available with planetary-gear speed reduction assemblies providing speeds of about 16.6, 3.3, 0.67, 0.133 or 0.027 rpm. Weighs 3 lb. Price, $36 without planetary gears. Superior Electric Co, Dept SS, Bristol, Conn.

Circle 325 on Reader Service Card

Pump-and-motor combination . . .

includes motors in NEMA 56 series ranging from ¼ to 1 hp, single- or three-phase, which may be combined with five different pumps with capacities from 20 to 360 gph at 200 psi. Over-all dimensions are 6$\frac{1}{16}$ x 11$\frac{33}{64}$ in. Tuthill Pump Co, 939 E 95th St, Chicago.

Circle 326 on Reader Service Card

Adjustable-speed drives . . .

are said to provide 1 to 2% regulation without tachometer feedback, to automatically drive machine tools and special-purpose machinery. Sensitive static feedback control can automatically be reset to follow unlimited number of input signals to change speed or mode of operation. Speed changes, acceleration, deceleration, precision slow-down, precision shaft rotation stop and dynamic braking and re-

continued on page 71

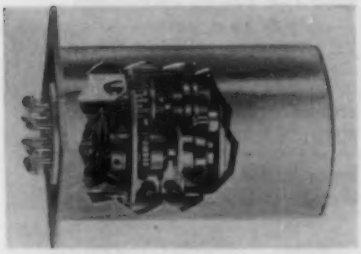
versing can be sequenced. Control signals can be received manually, mechanically, electrically or electronically. Inputs from punched tape can also be accommodated. Available with ratings from 1/40 to 3 hp; speed ranges as high as 50:1. **ECI Mfg Div, Electronic Controls Inc, 85 Magee Ave, Stamford, Conn.**

Circle 327 on Reader Service Card

Ductile permanent-magnet alloy . . .

said to possess high coercive force and energy product values, can be stamped, machined or otherwise formed by conventional methods into complex, intricately shaped parts that require no finishing operations. The copper-nickel-iron alloy is suited for use in applications requiring close-tolerance parts with strong directional magnetic properties. Now available as finished magnets formed or fabricated to meet specific requirements. Also offered as wire and strip in range of sizes, shapes and widths. **Hoskins Mfg Co, 4445 Lawton Ave, Detroit 8.**

Circle 328 on Reader Service Card



Miniature enclosed solenoids

are made to meet and exceed military requirements. Five standard types range from ½ to 1 in. dia, have high-temperature insulation, and are available in pull and push types. Designed for dc use only, miniature solenoids can be furnished with ratings up to 125 v. **Anderson Controls Inc, 9959 Pacific Ave, Franklin Park, Ill.**

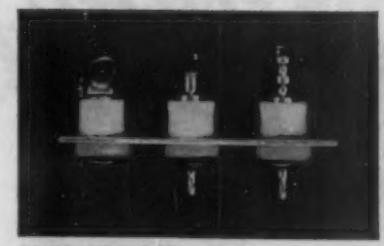
Circle 329 on Reader Service Card

Silicon rectifier stacks . . .

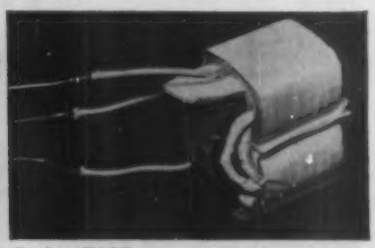
are preassembled for all basic circuit configurations, with peak inverse voltage ratings from 50 to 600 v and with current ratings from 2 to 35 amp. Stacks are said to retain low reverse current and forward drop, stability at high temperatures, and low initial and operating cost. Fins are nickel-plated, epoxy-coated copper and insulated with Melamine for 3000-w protection. Available in sizes of 2 x 2, 3 x 3 and 5 x 5 in., all 0.064 in. thick. Voltage-

continued on page 76

Design with versatile, POLYPENCO® Teflon* TFE shapes

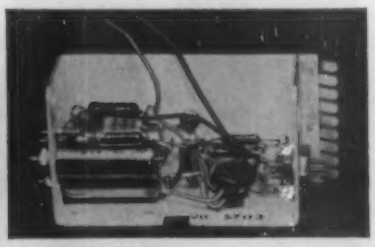


Machined from ROD
Insulators for high temperature hermetic feed-thru terminals, economically machined from POLYPENCO TFE-fluorocarbon rod. Used in transformers, capacitors, relays, etc., terminals have outstanding electrical properties and are relatively unaffected by heat or moisture.
(Photo courtesy, Lundey Associates)



Cut from TAPE
POLYPENCO TFE tape, operable at temperatures to 500°F., permits miniaturization of 42,000 volt transformer, reducing weight from 20 to 14 pounds. Heat resistance assists miniaturization since smaller transformers have higher temperature rises.
(Photo courtesy, Goslin Electric & Mfg. Co.)

Stamped from STRIP
TFE washer stamped from POLYPENCO TFE strip is spring clamped against idler wheel in record player. Low surface friction on contact permits easy turning of wheel. Resilience and non-adhesive characteristics were also important.
(Photo courtesy, Glaser-Steers Corp.)



Cut from TUBING
TFE spaghetti tubing in telemetering equipment maintains exceptional insulating properties at elevated temperatures, 100% relative humidity, and under constant vibration. Tubing is unaffected by soldering heats, and bending and flexing during assembly.

TEFLON SHAPES AND SIZES AVAILABLE FROM NATIONWIDE STOCK LOCATIONS

ROD
Diameter: ⅛″ to 7¼″ in various lengths

TUBING
O.D. ½″ to 12″
I.D. ¼″ to 6⅞″ depending on O.D.

SHEET
Thickness: 1/16″ to 2″
Sizes: 12″ x 12″, 24″ x 24″, and 48″ x 48″

TAPE
Thickness: .001″ to .125″
Widths: ¼″ to 24″
Ten fade-proof colors

SPAGHETTI TUBING
AWG sizes 30 to 0.
Thin and regular wall thicknesses
Ten fade-proof colors for coding

THIN WALL TUBING
I.D. ⅛″ to 1″
Wall thickness: .030″ to .050″

ROUND AND SQUARE BEADING
Round: Diam. .030″ to .150″
Square: .020″ to .156″ across the sides
Rectangular and Square Bars also available

DESIGN AND ENGINEERING HELP
Design and engineering assistance, or help on any industrial plastics problem is as near as your telephone—and yours without obligation. Take advantage of Polymer's experience and plastics know-how by calling or writing today!

**Du Pont TRADEMARK for fluorocarbon resins*

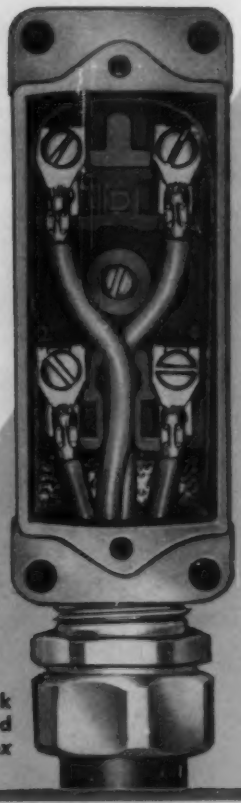
The Polymer Corporation of Pennsylvania
Reading, Pa.

POLYPENCO

This New PLUG-IN LIMIT

CLASS 9007, TYPE AW

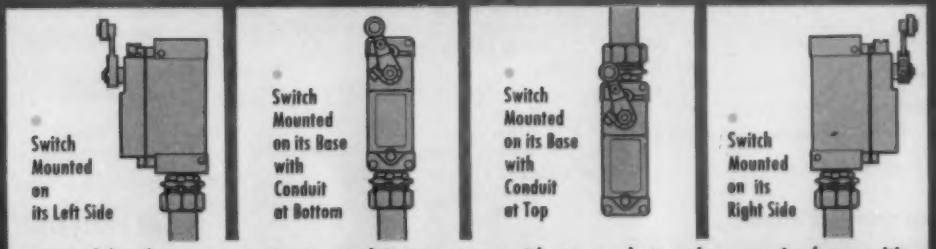
ACTUAL SIZE



Terminal Block Easily Wired *Without Removing from Box*

- Oil-tight construction
- Switch plugs in—in seconds
- Mounts without disassembly
- Wired without removing from box
- Reversible plug-in unit —can be plugged-in with roller arm at either end
- Switch action can be reversed by simple screwdriver adjustment
- Present installations easily converted to plug-in
- Precision switch mechanism —only 5° to operate— 25° overtravel in either direction
- Graduated markings around hub of roller arm simplify accurate settings
- Same price as standard Square D oil-tight limit switch

6 MOUNTING ARRANGEMENTS...WITH 1 DEVICE!


Switch Mounted on its Left Side
Switch Mounted on its Base with Conduit at Bottom
Switch Mounted on its Base with Conduit at Top
Switch Mounted on its Right Side

In any of the above arrangements, conduit can enter at either top or bottom by reversing box position

SQUARE D COMPANY

SWITCH is *SO EASY* to Use!

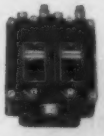
SQUARE D LIMIT SWITCHES ARE *Designed* TO DO HUNDREDS OF JOBS — BETTER!

SMALL OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE AW

Surface mounting, roller arm operated

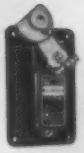
Flush mounting, push rod operated

Surface mounting, push rod operated



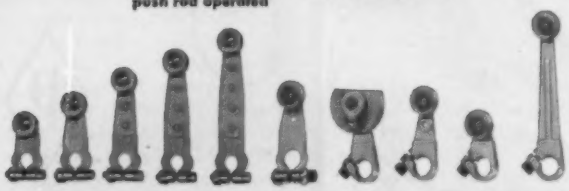
Duplex switch, surface mounting, push rod operated

Duplex switch, flush mounting, lever arm operated



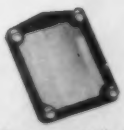
Flush mounting, lever operated

ROLLER ARMS AVAILABLE IN WIDE RANGE OF DESIGNS AND LENGTHS...

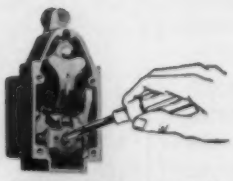


HEAVY-DUTY OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE T

Continuously adjustable lever arms, up to 80° overtravel



Transparent plastic cover available for instant inspection



Eleven contact arrangements in one switch; only a screwdriver is required

Rear shaft design for inaccessible locations

Many sizes and types of operating arms

WIDE VARIETY OF BASE PLATES AND MOUNTING HOLES...

Write for BULLETIN 9007 AW to Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

COLD-HEADED INTAKE VALVE

Lower in cost . . . better by test . . .

Engineered by NATIONAL LOCK

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FASTENER DIVISION Rockford, Illinois

74 CIRCLE 74 ON READER SERVICE CARD

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2. Carburetor Access Door
3. Motor Leg Exhaust Cover
4. Lower Shock Mount Cover
5. Upper Gear Housing
6. Lower Gear Housing

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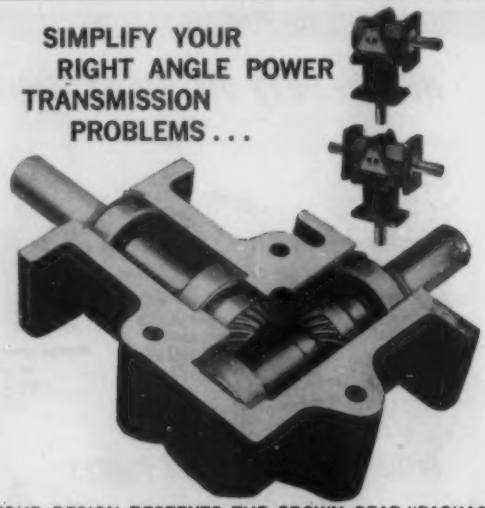

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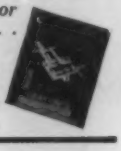

CROWN GEAR

320 PARK AVE., WORCESTER 10, MASS.

A Division of Harrington & Richardson, Inc.

CIRCLE 206 ON READER SERVICE CARD

dividing resistors are also available for stacks employing series cells. Two-wk delivery on all standard models. **Vickers Inc, Electric Products Div, 1815 Locust St, St Louis 3.**

Circle 330 on Reader Service Card

Rotary dc solenoids . . .

for applications where high torque and precision rotary motion is required. Available in five sizes: 8, 10, 13, 15 and 18. Can be supplied with any stroke length from 0 to 60°, clockwise or counterclockwise rotation. Operating voltages range from 6 to 300 v dc. **PSP Engineering Co, 6058 Walker Ave, Maywood, Calif.**

Circle 331 on Reader Service Card

Shock-overload indicator . . .

is sensitive to acceleration in one direction in longitudinal axis and in all transverse directions. Mounted with sensitive equipment, spring-loaded mass is tripped and bares red color spot behind clear plastic cover when excessive shock occurs. Unit measures 1½ in. dia x 1½ in. high. Two units, mounted back-to-back, provide full spherical sensitivity. Models available for most accelerations. Standard model is $20 in lots of 1000. **Convair Instruments, Convair Div of General Dynamics Corp, 3595 Frontier St, San Diego 10, Calif.**

Circle 332 on Reader Service Card

Three-in-one T-valve . . .

may be used as three-port valve with two ports in common, as a globe valve or as an angle valve. O-ring-type seal plug is furnished to close off one of three ports when used as globe or angle valve. Also, relief valve or burst disk can be installed in third port to provide a thermal safety or pressure-surge relief without extra plumbing. All-stainless steel valve weighs 1.06 lb. Has ⅞-in.-dia flow passage, excellent metering characteristics, low operating torque and operating temperature range of —65 to 250 F. **Robbins Aviation Inc, 2350 E 38th St, Los Angeles 58.**

Circle 333 on Reader Service Card

Direct-acting venturi valve . . .

is combined with optically flat floating-seal principle to provide straight-through flow path without obstructions. Pressure-recovery characteristics of venturi design allow reduction of fluid line ID to relatively small throat. This permits use of minimum-weight, direct-acting solenoid. Maintains dielectric strength under salt spray, temperatures to 500 F and other adverse environmental conditions. Both valve and solenoid are rated from zero to 255 psi, over temperatures of —65 to 250 F, with fluid temperatures between —30 and 350 F and up to 550 F for 10 min. maximum. In 1-in. line size, valve weighs 1¾ lb. **Valcor Engineering Corp, Kenilworth, NJ.**

Circle 334 on Reader Service Card

Stepless power-input controller

is electrothermally actuated and permits setting of any percentage of time from 5 to 100%. Automatically compensates for wide variations in voltage and ambient temperature. Built-in magnetic-arc suppression is said to lengthen contact life and to reduce sparking hazards. Circuit is rated 115 v ac, 1500 w. By accurately switching power on and off in preselected rhythm, controller can be used to control flask heaters, mantles, heating tapes and other equipment. Price is $15.75, FOB Dubuque. Immediate shipment. **Thermo Electric Mfg Co, 465 Huff St, Dubuque, Iowa.**

Circle 335 on Reader Service Card

Sealed time-delay timer . . .

is factory-set for time cycles from 1 sec to 60 hr. Features automatic reset. Switch rating is 5 amp at 115 v, 60 cps. Contacts are SPDT. Operates on 6 to 230 v, 25, 50, 60 or 400 cps; 6, 12, 24, 28, or 115 v dc. Reported to meet specifications of MIL-T-4807, shock and vibration, methods 1A, 3A and 5A; MIL-E-5272B, humidity, salt spray, high and low temperature, barometric pressure, and life test; MIL-R-5757. Delivery, 8 to 10 wk. Price for single unit, one-switch model, 115 v, 60 cps, is $53.50. **Industrial Timer Corp, 1407 McCarter Highway, Newark 4, NJ.**

Circle 336 on Reader Service Card

Torque-tension testing units

have been aded to line of three basic models. Larger in size than their American counterparts, two new models, developed by British company, feature oversize gages for more accurate reading than heretofore possible. One gage reads in pounds of load or tension, in increments of 50-lb; the other in ft-lb of torque, in increments of 1 ft-lb. First of new models is designed for bolts from ⅜ to ½ in. and for torque up to 150 ft-lb and loads up to 10,000 lb; the second model can be used for bolts from ½ to 1 in. and for torques up to 1000 ft-lb and loads up to 80,000 lb. **Skidmore-Wilhelm Mfg Co, 442 S Green Rd, Cleveland 21.**

Circle 337 on Reader Service Card

Mechanical force gages . . .

for measuring tension in permanent test setup has free-floating transmission rod, which transmits tension load to dial indicator. Holds max dial reading after load has been removed. Available in capacities of 20, 50, 75, 100, 150, 200 and 500 lb. Measures all forces up to max capacities with accuracy of ±0.1 lb for 20-lb unit; ±¼ lb for 50-lb model; ±½ lb for 75- and 100-lb models; ±1 lb for 150- and 200-lb models and ±2½ lb for 500 lb model. **Hunter Spring Co, Div American Machine & Metals Inc, 1 Spring Ave, Lansdale, Penna.**

Circle 338 on Reader Service Card

Desk conceals drawing board

under desk top. Board is elevated into posture-chair height by rising mechanism when desk top is opened. When desk top is closed, drawing board is automatically lowered in flat plain into well that has sufficient clearance between board and desk top for permanent mounting of drafting machine. Provides storage for drawings, drawing paper, reference books, catalogs, files and tools. Available in different styles, desk-top sizes, electrical outlets, locks and drawing-board pencil trough. **Densmore Calculator Co, PO Box 1557, Oakland 4, Calif.**

Circle 339 on Reader Service Card

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Study the polished perfection of this hollow plunger, flawless in line and form → literally a gem in metal.

This beautiful threaded stainless steel plunger is vivid proof that the old-time skill of the jewelry craftsman still prevails at Spincraft, the founder of industrial metal spinning.

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76 CIRCLE 76 ON READER SERVICE CARD

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- **For inside and outside application. All sizes. Immediate delivery.**

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DESIGN LITERATURE

Design Analysis for Long-duration Occupancy

BENNETT, KEMLER et al, Bio-Mechanics Laboratory, Tufts University. PB1511681. Office of Technical Services, Dept of Commerce, Washington 25, DC. 33 pp, 8¼ x 10¾. $1.25.

This report (full title: "The Polydiagnostic Method of Multiple Forced-choice Rankings in Design Analysis") is one of a series evaluating man's life requirements in confined operational areas, such as long-range aircraft, submarines and, eventually, manned satellites and space vehicles. Such "life-space" situations have in common the fact that the occupant cannot leave them for extensive periods of time, and any mistakes or shortcomings in their design or apparatus can easily become critical to the operating system as a whole.

A method of obtaining the guidance of typical users of equipment being designed is discussed, particularly as it was applied in this study. Known as "multiple forced-choice rankings," results of applying the method to the design analysis of an aircraft-crew seat are given.

Standardizing and Communicating Product Appearance

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9, 22 pp. $2 (nonmembers); $1.60 (members).

This is the proceedings of a "Symposium on Visual Aids for Standardizing and Communicating Product Appearance." Includes a survey of the ASTM's methods and standards for evaluating such appearance factors as color and finish. This discussion also contains some material on the textile industry dealing with this problem. A summary points out some of the possible methods of improving controls.

Direct-current Electricity

ALEXANDER EFRON. John F Rider Publisher Inc, 116 W 14th St, NYC. 5½ x 8½, 100 pp. $2.25.

Subtitled the "Franklinian Approach" (that is, plus-to-minus flow of currents), this book covers the fundamentals of direct-current electricity from the viewpoint of, among others, the student of electrical engineering.

Electrochemistry forms an early portion of the text, together with related ionization theory and analysis of primary and secondary cells. The concept of voltage drop is discussed and worked into an analysis of series and parallel circuits. The basic types of movements employed in measuring instruments are reviewed, together with their applications. The magnetic effects of electric current are presented, as well as the laws of magnetism. Examples are given and supplementary questions and problems are included at the end of each chapter.

Other Books of Interest

Investigation of Fatigue Properties at Room Temperature of High-strength Steels Having High Tempering Temperatures

PB 161144. Cummings, Stulen, Schulte. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 95 pp. $2.50.

Practical Solution of Plastic-deformation Problems in Elastic-plastic Range

Mendelson, Manson. Superintendent of Documents, US Govt. Printing Office, Washington 25, DC. 8 x 10¼, 24 pp. 40¢.

Aeronautical Dictionary

Frank D Adams. Superintendent of Documents, Government Printing Office, Washington 25, DC. 6 x 9, 199 pp. $1.75.

Lists and defines about 4000 aeronautical terms.

Effects of Solute Elements on the Strength Properties of Iron- and Cobalt-base Alloys

PB 161043. Wolff, Underwood, Maringer, Manning. Office of Technical Services, Dept of Commerce, Washington 25, DC. 71 pp. $2.

ABSTRACTS FROM THE LITERATURE

Thermoelectricity

A review of past, present and future developments is presented. Some modern products depending upon thermoelectricity are illustrated.

"A Ray From the Brighter Tomorrow . . . Thermoelectricity, Capt Norbert Frankenberger, USN, and Lt John C. Cooper, USN. Bureau of Ships Journal, April '60, Bureau of Ships, Dept of the Navy, Washington 25, DC.

High-speed Machining

Missiles and high-performance aircraft require alloys to withstand high temperatures while retaining high strength for structural integrity. But these alloys are difficult to machine by conventional methods. This paper reviews a method that removes metal with an ultrahigh-speed machining projectile.

"Recent Developments in Ultrahigh-speed Machining," Robert L. Vaughn, Lockheed Aircraft Corp, and Robert T. Krueck, Wright-Patterson Air Force Base. ASTME technical paper, American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave, Detroit 38.

Fractures in Aluminum

An understanding of fracture patterns often will give a valuable clue as to the cause of failure of a welded joint. Defects in weld metal, such as hot cracks and crater cracks, will exhibit a fracture pattern quite unlike that of sound weld metal. The purpose of this paper is to help the observer recognize this unusual pattern and to understand its significance.

"How to Interpret Fractures in Aluminum Weld Metal," William L. Burch, Bell Aircraft Corp, Buffalo, NY. Welding Journal, Apr '60. 20th and Northampton Streets, Easton, Penna.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard lists inside back cover.

WORM-GEAR SPEED REDUCERS — Catalog 2824, 66 pp. Covers line of fan-cooled worm-gear speed reducers available in ratios from 4:1 to 3600:1. Selection data includes rating tables arranged according to speed as compared to ratio. Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.

Circle 350 on Reader Service Card

STEEL AND BRASS FITTINGS—Form 6173, chart. Presents complete range of flared, flareless and pipe fittings analyzed by fitting styles, typical applications, types of tubing used, pressure, temperature and vibration ratings, application advantages and disadvantages. Weatherhead Co, 128 W Washington Blvd, Ft Wayne, Ind.

Circle 351 on Reader Service Card

CHROMIUM-NICKEL STAINLESS — Brochure, 40 pp. Contains general information, properties and specifications of chromium-nickel types of stainless steel—300 Series. Republic Steel, 1441 Republic Bldg, Cleveland 1.

Circle 352 on Reader Service Card

STAINLESS WIRE — Manual, 20 pp. Covers chemical analyses and mechanical properties of all grades of stainless steel used in wire and recommendations for the

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EMPLOYMENT OPPORTUNITIES

NATIONAL COVERAGE

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

Positions Vacant	Civil Service Opportunities	Employment Agencies
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Men who read more...earn more!

application of representative grades in almost 400 corrosive environments. Stainless and Strip Div, Jones & Laughlin Steel Corp, Box 4606, Detroit 34.

Circle 353 on Reader Service Card

INDUSTRIAL TRANSFORMERS – Catalog TR-61, 36 pp. Lists over 1000 items with specifications, dimensions and ratings. Triad Transformer Corp, 4055 Redwood Ave, Venice, Calif.

Circle 354 on Reader Service Card

INSTRUMENT POWER TRANSMISSION–Booklet, 12 pp. Describes line of 12-speed instrument drives, geared adapters, single and double gearboxes, tachometers, actuators, and flexible shaft and clutch assemblies. Actuator Products, Div of Geartronics Corp, PO Box 247, Woburn, Mass.

Circle 355 on Reader Service Card

ROUND-EDGED STRIP STEEL – Brochure, 8 pp. Describes service to provide round-edge, cold-rolled flat wire and round-edge strip in all thicknesses, widths and tempers. Contains table of estimated weights of cold-rolled strip steel. Caine Steel Co, 5501 W Grand Ave, Chicago 39.

Circle 356 on Reader Service Card

TEMPERATURE CONTROLS – Bulletin 108, 12 pp. Explains operation, circuitry and safety features of three basic types of thermocouple-actuated temperature-control packages. Includes prices. Assembly Products Inc, Chesterland, Ohio.

Circle 357 on Reader Service Card

ALUMINUM AND ZINC CASTING DATA–House organ, Vol. I, No. 1. External house organ, Monarcasting, is to be published quarterly. Monarch Aluminum Mfg Co, 9205 Detroit Ave, Cleveland 2.

Circle 358 on Reader Service Card

SEAMLESS TUBING – Bulletin 60, 12 pp. Describes manufacturing capabilities and outlines properties and applications of various alloys. Uniform Tubes Inc, Collegeville, Penna.

Circle 359 on Reader Service Card

POWER-STEERING SYSTEMS – Brochure M-5100, 16 pp. Describes line of production-built power-steering components that can be combined to suit most steering-axle load requirements. Includes component-selection tables, performance curves and typical examples. Vickers Inc, Div of Sperry Rand Corp, Detroit 32.

Circle 360 on Reader Service Card

LAMINATED PLASTICS – Selection guide, 12 pp, and wall chart. Manual describes high-pressure laminates, property values and how they differ from specifica-

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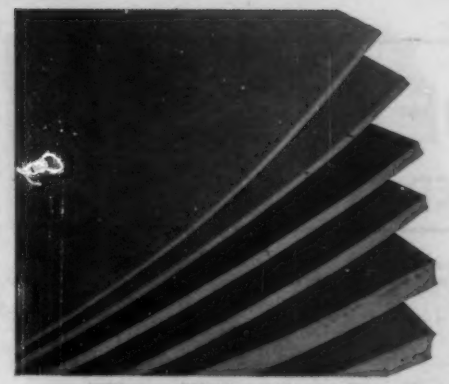

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free bulletin 909

contains complete information. Write Formica Corp., a subsidiary of American Cyanamid, 4516M Spring Grove Ave., Cincinnati 32, Ohio.

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tion properties listed for metals. Chart presents characteristics for 21 commonly used laminate grades. Taylor Fibre Co, Norristown, Penna.

Circle 361 on Reader Service Card

MILL PRODUCTS AND ALLOYS—Brochure 83-360-5R, 12 pp. Review full range of shapes, sizes and alloys available in primary aluminum pig, ingot and billet and in wrought aluminum mill products. With metallurgical tables and design information. Harvey Aluminum, Torrance, Calif.

Circle 362 on Reader Service Card

INSULATING RESINS — Bulletin, 6 pp. Illustrated guide to E Series of epoxy formulations for potting, impregnating, dipping and coating electrical and electronic parts, products and assemblies. Marblette Corp, 37-31 30th St, Long Island City 1, NY.

Circle 363 on Reader Service Card

ELECTROMECHANICAL CONTROL SYSTEMS—Bulletin EE-1008, 6 pp. Contains information on point-to-point control systems, speed-control systems and fhp and integral-horsepower servosystems as well as control-system components. Seneca Falls Machine Co, Electronics Div, 12 Fyfe Bldg, Seneca Falls, NY.

Circle 364 on Reader Service Card

COBALT-BASE AND COBALT-CONTAINING ALLOYS—Data sheets, 4 pp. Properties, composition and application information. Cobalt Information Center, c/o Battelle Memorial Institute, 505 King Ave, Columbus, Ohio.

Circle 365 on Reader Service Card

MAGNESIUM AND ALUMINUM ALLOYS—Brochure, 4 pp. Mechanical properties, composition, characteristics and typical applications of high-temp magnesium alloy and high-purity aluminum alloy. Bendix Foundries, Bendix Aviation Corp, Teterboro, NJ.

Circle 366 on Reader Service Card

IMPULSE-COUNTING DEVICES — Bulletin, 4 pp. Describes specifications of electric and manual reset counters, monodecade and predetermining counters, short counters with pushbutton reset, hours-minutes-seconds indicators, printing counters, heavy-duty counters and impulse transmitters. Landis & Gyr Inc, 45 W 45th St, New York 36.

Circle 367 on Reader Service Card

ELECTROMECHANICAL COMPONENTS—Short form catalog SE-60, 4 pp. Covers principal lines of measuring, indicating, recording and controlling devices, including specifications, application dia-

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grams and performance curves. Schaevitz Engineering, PO Box 505, Camden 1, NJ.
Circle 368 on Reader Service Card

EPOXY-BASED PLASTIC MATERIALS—Price list 8 pp. Basic list covers 25 products with prices stated singularly for resin and hardener. Accessory price list covers glass cloth ribbon, parting and mold-release materials, plastic tubing, glass fibers, brushes, plastic-coated gloves, spreaders and mixing paddles. Ren Plastics Inc, Dept RP-55, 5422 S Cedar Rd, Lansing 9, Mich.
Circle 369 on Reader Service Card

ROTARY SWITCH—Brochure, 4 pp. Describes lightweight rotary switch that completes up to 100,000 contacts per min. with no bounce. Text describes high-speed operation, circuit arrangements and voltages and construction. Lists specifications and environmental characteristics. Circuit Controls Co, Div Genge Industries Inc, 1500 E Colorado St, Glendale 5, Calif.
Circle 370 on Reader Service Card

STOCK AND SPECIAL GEARS—Bulletin, 4 pp. Contains information on bevel, helical, miter, worm and spur gears for industrial power-drive requirements. Ohio Gear Co, 1200 E 179th St, Cleveland 10.
Circle 371 on Reader Service Card

PROJECTOR-PRINTER—Bulletin, 4 pp. Describes electrostatic system capable of making prints from 8½ x 11 to 34 x 48 in. from miniature negatives. Finished print is produced in 40 sec. Keuffel & Esser Co, Third and Adams Sts, Hoboken, NJ.
Circle 372 on Reader Service Card

ROTARY SOLENOID—Engineering data sheet, 2 pp. Describes D-size, 112 in.-lb-degree rotary solenoid, available in four stock models. Includes information on performance, size, voltage requirements, and duty cycles; contains engineering and torque charts. Pacsol Div, Illinois Tool Works, 3155 El Segundo Blvd, Hawthorne, Calif.
Circle 373 on Reader Service Card

SHOCK AND VIBRATION ISOLATOR—Bulletin 59-04.5, 2 pp. Covers construction, specifications, and performance of combination shock and vibration isolator. Barry Controls Inc, 700 Pleasant St, Watertown, Mass.
Circle 374 on Reader Service Card

GEAR-REDUCED MINIATURE MOTORS—Bulletin 135, 2 pp. Describes ⅞-in.-dia permanent-magnet precision miniature motors with integral planetary gear reducers in 21 ratios. Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.
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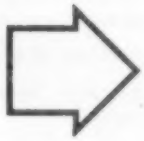

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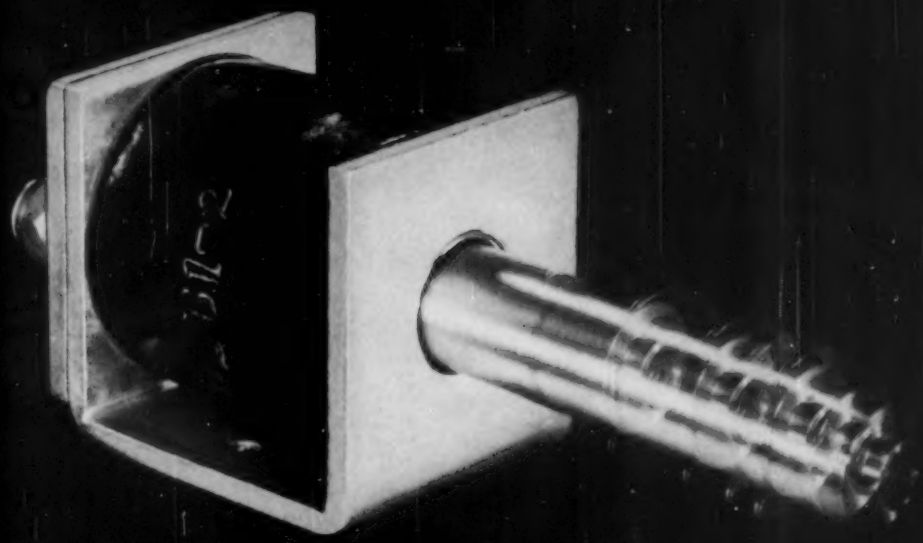

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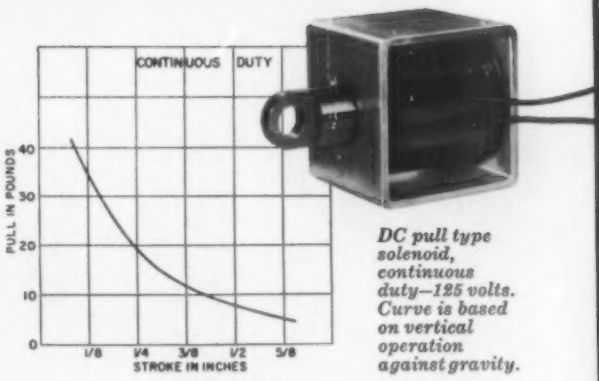

DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

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Automatic Switch Co. 54-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

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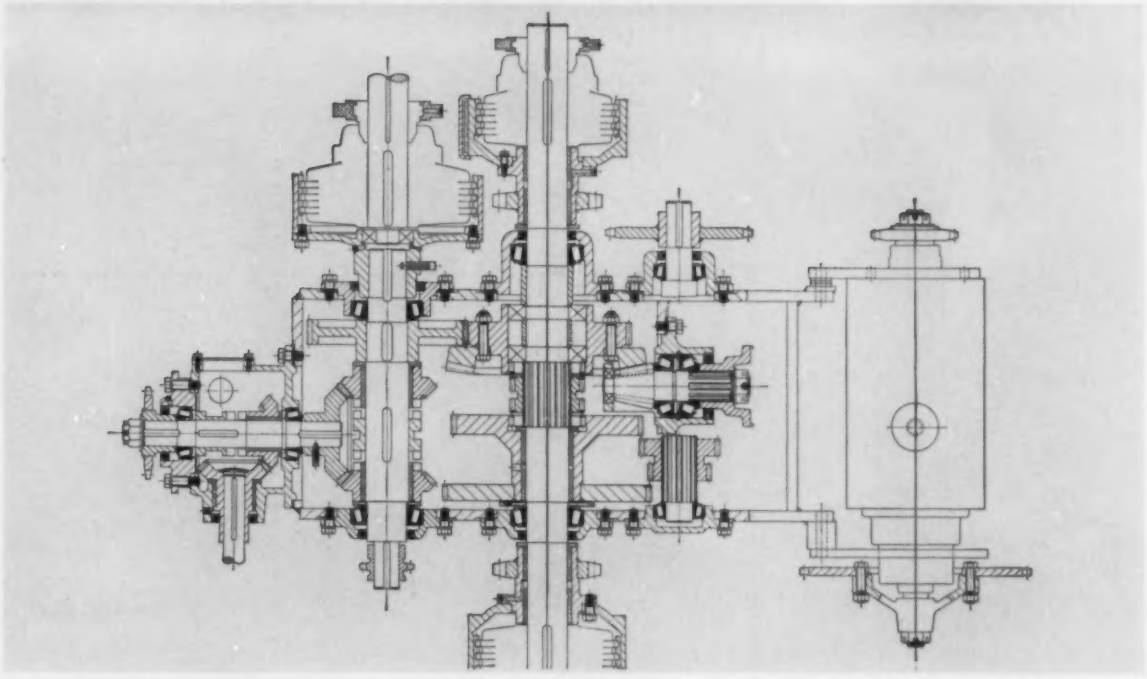
CIRCLE 202 ON READER SERVICE CARD

How Parsons mounts shafts to take heavy loads, keep Trenchliner digging



Parsons Company engineers used 10 Timken® tapered roller bearings to help solve load-carrying problems in their Model 150 Trenchliner. Radial and thrust loads are heavy as the Trenchliner digs fast—25 fpm., digs deep—5′9″, digs wide—26″. By using Timken bearings in the transmission assembly shown above, their engineers assured positive alignment of gears and shafts under all loads. Digging goes steadily. For more than 40 years construction equipment engineers have used Timken bearings because: 1) The taper lets Timken bearings take radial and thrust loads in *any* combination. 2) By holding shafts concentric with housings, Timken bearings make closures more effective in keeping lubricant in, dirt out. 3) The extra load carrying ability of Timken bearings takes care of the rugged going and provides longer life.

TIME-AND-MONEY-SAVING ENGINEERING SERVICE. Often our graduate engineer salemen can solve your bearing problems on the spot, help you design the most economical applications.

WEATHER CONTROL "LAB". We test bearing performance under all conditions of operation, including temperatures as low as −60° F. to make sure Timken bearings roll the loads anywhere and in any weather.

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